THE
PEDAGOGICAL SEMINARY

Founded and Edited by G. STANLEY HALL

VOL. XXVII DECEMBER, 1920 No. 4

METABOLISM IN CHILDHOOD

By WILLIAM H. BURNHAM, Clark University

What is the physical difference between a child and an adult? The answer of the naïve observer may well be that the child is small and the adult is large. From the scientific point of view also this is really one of the differences of fundamental significance. It is important, not merely because of the difference in the mechanical proportions of a small body as compared with a large body, but still more significant because the response to stimulation is different in a small body from what it is in a large body. In other words, the smallness of the child's body is significant because it is one of the conditions of greater metabolism in the young. The fact of this greater metabolism is well known. The reason for it is in dispute.

Unfortunately few studies have been made of the metabolism in children. The old investigations by Magnus-Levy and Falk indicated that the basal metabolism in infancy is low, that it is high in childhood, and low again after the onset of old age. Harris and Benedict conclude that metabolism decreases throughout adult life. One of the objects of the investigation of basal metabolism at the Carnegie nutrition laboratory has been the determination of the changes that take place throughout the entire period of life. But in the opinion of Harris and Benedict the time is not yet ripe to chart these changes. In general form, however, Dubois has attempted to present the curve of metabolism. He describes this as follows (17, p. 109-110):

"During the first few weeks of life the metabolism is very low, after which it rises rapidly until at the end of the first year it is 50 per cent above the adult level. The curve reaches

its acme in the almost unexplored period between two and six years and then falls fairly rapidly until the age of twenty years. After this the decrease is extremely gradual."

One of the facts brought out clearly by the various studies of metabolism in relation to age, is that throughout the whole range of adult life the heat production of the individual decreases. This is thought to be due to definite and progressive physiological changes in the tissues of the organism with increasing age. We refer to this in general terms as due to the greater vitality of the young; but this is a part of the great mystery of growth and development. We recognize the fact, but we cannot explain it. We can, however, inquire in regard to the conditions of this greater metabolism. There are two theories: first, is the theory of Camerer(15) and Rubner(32) and the view that has generally been accepted.

These writers maintain that the greater metabolism in the young is conditioned by the relatively greater skin surface of the small body of the child as compared with the large body of the adult, and the greater part of the metabolism is necessary to supply the loss of heat radiated from the surface of the body. Camerer starts with the fact that the surface of a small body is much greater in proportion to its weight and its content than that of a large body. If we take, for example, two bullets of lead, one of 2 centimeters in diameter, the other of 4 centimeters in diameter, and attempt to maintain them at the same temperature, more heat is required to do this in case of the small one per unit of weight than in case of the larger one, because the heat radiated from a body is proportional to its surface and not to its content or its weight; and the small body on account of its relatively larger surface loses heat more rapidly than the large body.

In like manner the small body of a child has relatively larger surface in proportion to its mass than the large body of the adult. There is greater loss of heat by radiation, and a greater amount of food must be taken and transformed into heat in order to compensate for this loss. Hence children, for each kilogram of body weight, produce a greater amount of energy than adults. The same is true of a dwarf and of small animals as compared with large. Thus, according to Camerer, the amount of nourishment required depends chiefly on the amount of surface of the child's body. And the child needs relatively more food than the adult because he is small.

The views held by Camerer and Rubner are similar, but Rubner has worked his out with great elaboration and formulated his stereometric law to the effect that the expenditure of energy is constant for each unit of body surface. This

famous law is substantially as follows: Warm blooded animals, in order to keep their body temperature constant, must produce a constant amount of body heat for each unit of body surface. Therefore the metabolism must be constant for each surface unit. As much heat must be produced in a given period of time as is lost by the surface; or, as Schlossman and Camerer express it, the essential part of the metabolism serves for renewing the heat that is lost by radiation. As Rubner (32, p. 196) formulates it, metabolism is directly proportional to the surface area of the body; and for each unit of skin surface large animals and small animals, elephant, lion, or mouse, have the same heat production. This stereometric law (32, p. 148) seems to be universal among mammals. For every species, it is maintained, definite figures for the heat production can be established for each square meter of body surface. These are constant for definite physiological conditions—rest, temperature, nourishment, and normal physical condition. Thus metabolism is determined.

We may well be suspicious of any mechanical theory of the human organism. The body is not a mechanical object like a stove whose function is merely to produce a certain amount of heat and incidentally boil the water in a tea-kettle, but rather it is a mechanism for producing complex organic functions with which its metabolism is necessarily correlated.

Harris and Benedict (20) have made a thorough-going study and critique of the body surface law, and have shown that by the Meeh formula the body weight gives practically as good a basis for prediction of heat production as the body surface. They point out many defects in the law, among others the following: It does not hold under widely varying states of nutrition. For the fasting individual the body surface law does not hold. It does not hold in certain pathological conditions. Again heat loss does not occur exclusively through the skin. A considerable part of the total heat generated is given off by the lungs and by the vaporization of water. "Finally," they conclude, (20, p. 200) "in view of the facts that (a) the equations developed in this volume and the convenient tables which have been provided for the prediction of the basal metabolism of the individual from stature, weight, and age deprive the 'body-surface law' of its unique practical significance, and that (b) the evidence of an actual physiological nexus between body-surface area and metabolism is altogether inconclusive, it seems to us that the 'body-surface law,' as far as its supposed application to the human individual is concerned, must play a very minor rôle indeed in future physiological discussions."

An extended study has been made also by Pütter(30) of the active surface of physical organs in relation to function. The outcome of this investigation is to show that in case of mammals the development of the body surface is not the determining factor for the intensity of the metabolism.

In the present condition of our knowledge of metabolism we can get a very good orientation in regard to the total exchange of an animal if we merely have sufficient data in regard to its food. Putter gives an estimate of this on the basis of data furnished in Kellner's *Lehrbuch* and according to König for carnivorous animals. In this case the food is practically completely digested except the bones. Pütter has estimated this for a lion weighing 200 kilograms and a sea-lion weighing 110 kilograms, an ox, a horse, an elephant, a camel, and one or two other animals; and he presents a table comparing these results with those for the small mammals like the mouse, rat, cat, sheep, and the like.

The exchange for the mammals mentioned in relation to the body surface shows a difference of about 6.65 times, hence one can not at least speak of any constant of exchange. The two water mammals which for unity of body surface show almost exactly the same exchange, 3,400 and 3,500 calories, exceed the relative exchange in the case of man more than double, and, finally, the elephant and camel per unit of surface exceed that of man three to four times. Pütter (30, p. 201) makes certain corrections for differences in the bodily shape in these animals as compared with man, but these are not great; and hence he concludes that the development of the body surface is not the determining factor for the intensity of metabolism in mammals.

Rubner's investigations were most painstaking and extended. They represent a kind of pioneer work that is especially important. The fate, however, of the investigator in a new field is likely to be that many of his results are shown by later investigation to be erroneous. The significance of the pioneer work is that it leads to further investigation. Judging from this point of view the studies of Rubner have been of prime importance. From the point of view, however, of the larger problem, they are inevitably superficial and in part the results are erroneous.

This stereometric law of Camerer and Rubner has played a tremendous rôle in physiology and the study of metabolism. The difficulties connected with it and the defects likely to be connected with it, have been discussed at length by Harris and Benedict in their new book, " A Biometric Study of Basal Metabolism in Man."(20)

The fundamental defect of this so called law, however, is not its inadequacy as a statement of the mechanical facts, but still more serious, its failure to represent the vital and significant facts of a growing and developing and functioning organism. Strangely enough this defect seems to have received little attention from physiologists and special students of metabolism. It will appear from a view of the other theory.

The other theory takes account of the common characteristic of the child and the adult noted at the outset, namely, that both are mechanisms for converting stimuli into reactions, and puts the emphasis on function. Professor Kassowitz has developed this, although it is based, I understand, on earlier work by Pflüger. Rather strangely this theory seems to be little known and the name of Kassowitz is seldom quoted by American students of metabolism. This neglect, I fancy, may be due to the fact that Kassowitz's theory as regards the greater metabolism in the child, appeared in the *Jahrbuch für Kinderheilkunde* (22) and the *Zeitschrift für Kinderheilkunde* (23), and, did not, so far as I am aware, appear in the Journals of Physiology. It is, perhaps, an illustration of the way child hygiene has been neglected.

According to this theory the reason for the greater metabolism in the young is the fact that in a small body the nerve paths are shorter and the response to stimulation quicker. All the vital processes go on more rapidly; and heat is a by-product of this functional activity. The food taken into the body is used to build up protoplasm; and under the influence of varied stimuli this protoplasm breaks down producing the energy which functions our reactions. The significance of the smallness of the child's body as compared with that of the adult lies chiefly in the fact that in a small body the reflex arcs have shorter members and reaction follows stimulus more quickly. This brings us to the heart of the theory of Kassowitz, and we may approach it from the psychological point of view.

All students of psychology and physiology are familiar with the following experiment. Place a drop of acid on the thigh of a decapitated frog and immediately the muscles of the frog's leg contract and the leg is lifted to brush off the irritating stimulus. This simple reflex act is the type of all our activity. First, a receptor organ and an incoming nervous current along an afferent nerve; second, an adjustor and more or less complicated central process; and then third, a discharge along an efferent nerve to inervate a muscle or gland, an effector organ. The stimulus is an essential condition of the reaction. In the case of continuous movements, according to the common

view, the movement itself, or the kinaesthetic sensation if you prefer, acts as a stimulus for the succeeding movement, and thus continued movements are kept up automatically. According to Prof. Kassowitz, not only is this true of our ordinary automatic movements but it is true also of those alternating or rythmical movements so important in the body, the movements of the heart and of respiration, as well as the movements of locomotion and the like. The systole and dyastole of the heart, inspiration and expiration, the raising and lowering of the wings of the birds or the fins of the fish, the contraction and extension of the limbs, follow each other in an unbroken and long continued sequence. This is not the whole story; but it is essentially true and it is the view of Kassowitz. That is, the supposed automatic movements are to be referred back to reflexes for which the stimuli are found in kinaesthetic sensations from the muscles and the parts moved by them.

In simpler words, each movement furnishes the stimulus for the next movement. Thus the continuous movements of an automatic act like walking consist of a series of reflex arcs, according to the view now genèrally accepted by physiologists. In like manner arise in case of the heart and respiration those movements which continue throughout the whole of life, and each of these reflex arcs has of course its centripetal and centrifugal arm whose length is naturally dependent on the size of the animals. But since we know that the velocity of the nervous processes is the same in small animals and in large, the interval between the separate phases of a similar movement in the case of large animals with longer nerve paths must be correspondingly greater than in the case of smaller ones. This deduction from the theory of the reflex arc is corroborated by the facts observed in regard to the rapidity of fundamental movements in the large animals as compared with small ones.

It is interesting how frequently in the various sciences we have to go back to the great discoveries of Helmholtz. About the middle of the last century when Helmholtz was studying the rate of the nervous current in the frog's nerve, the great Johannes Müller was teaching his students that the rate of the nervous impulse was infinitesimal—*unendlich klein, und unmessbar.*

The young Helmholtz, however, demonstrated that the rate of the nervous impulse is relatively slow, namely, in the frog about 30 meters a second, and later showed that for warm blooded animals it is about 34 meters a second, that is, about the rate of an express train. In man the rate of the nerve current is about that of the fastest express train, 100 meters or more a second. Thus we find this striking difference as regards

these movements; in small animals they follow each other more quickly, in large animals more slowly. The heart of the elephant beats twenty-five to twenty-eight times in a minute, that of the adult cat 130 to 140 times a minute. The heart of the newborn child contracts about 130 times a minute and that of a child of six about 100 times, that of an adult about 70 times. Much the same is true of respiration. In the case of the newborn child the respiration is about 35 per minute; at the age of six it is perhaps 25 per minute; in the case of the adult about 13 when lying down, and 22 when standing, with of course great individual variations. Again in the case of the smaller mammals and birds the number of contractions of the heart are much more frequent, and there is a similar difference between the movements of the wings in large animals and in smaller animals, with the slow movements of the large birds on the one hand, and the rapid movements of the wings of the housefly on the other, 360 times in a second.

Miss Buchanan(12) has given tables showing the estimated frequency of the heart beat for different animals. The number of determinations has been small, but while the exact numbers given cannot be taken as very reliable, the difference between the heart beat in large animals and small animals is obvious. Some of the figures in her table for mammals are as follows, the number representing in each case the average when the animal is at rest. For the mouse, 700 per minute; for the guinea pig, 300; cat, 160; rabbit, 205; medium sized dog, 120; large dog, 85; sheep, 75; ox, 48; horse, 37.

In a word then this is the theory. Both large animals and small animals are machines for converting stimuli into reactions. The smaller animals with shorter nerve paths react to stimuli more quickly; and this, according to Kassowitz, is the chief cause of their relatively greater expenditure of energy and metabolism. And heat and energy according to Kassowitz are caused by the breaking down of the complex protoplasm molecules on occasion of stimuli from the afferent nerves.

Kassowitz has formulated this view as follows: small animals do not sustain more oxidation per unit of weight than larger ones because on account of their relatively greater body surface they lose more heat than the latter, but for the reason that their alternating movements, whose later phases are always produced reflexly by the earlier ones, on account of the shorter nerve paths more quickly succeed each other. The same relation prevails in case of cold-blooded animals, where an increased combustion for the sake of satisfying the need of heat is manifestly excluded.

By the fact that the ratio of metabolism between large and small individuals in case of cold blooded animals is the same as it is in the case of warm blooded animals, the teleological significance of the increased production of heat in the smaller individual is disproved.

Against this causal explanation that by the shorter reflex paths the alternating movements including the continuously active movements of the heart and respiration which produce heat repeat themselves in a period of time more often, and consequently more heat must be created by them, there cannot be raised any serious objection. Examples are plenty.

That the metabolism is correlated with the pulse rate there is apparently good evidence.

Benedict and Cathcart have made many tests which show that after muscular work there is increased pulse rate and increased metabolism. They say (6, p. 172):

"The intimate relationship between the pulse-rate and the metabolism is strikingly emphasized by the distinct tendency shown for the pulse-rate to assume a much higher level after work than before—a level that is roughly approximate to the increase in the total metabolism. The respiration-rate, on the other hand, does not alter greatly. Since they were reported primarily to show the influence of muscular activity on the pulse-rate, the observations of Pembrey are of interest here. One of his subjects before the test had a pulse-rate of 70; immediately after running 2 miles, the pulse-rate was found to be 164; 10 minutes later, 128; 30 minutes later, 100; and 60 minutes later, 82. Another subject had a pulse-rate before running of 66; immediately after running the 2 miles, the pulse-rate was 140; after 2 minutes, 120; after 33 minutes, 106 after 77 minutes, 84; and 107 minutes afterwards, 74. A second test with the same subject showed a pulse-rate before running of 56; immediately after the run, 136; 15 minutes afterwards, 104; 45 minutes afterwards, 88; and 75 minutes after, 86. In all of these observations, it will be seen that the pulse-rate remained at a considerably higher level after the exercise than the resting value obtained before the run."

There is evidence also that, in general, the metabolism is correlated with the muscular activity. Benedict and Carpenter (5, p. 243) have made experiments which show that the ordinary processes of sitting, standing, walking and general muscular exercise condition metabolism.

"When the subject is quietly seated in a chair, the metabolism is invariably somewhat higher than when he is lying on a bed asleep. If a subject is trained to so regulate the muscular tension by his will as to reduce it to the minimum, the differences in the carbon-dioxide excretion during such muscular relaxation when lying down awake and when asleep are not measurable. On the other hand, sitting up calls for a different readjustment of the muscular system with variations in the tonus, and the sitting posture does not permit of as com-

plete a relaxation of muscular tension as does lying down. Standing requires a still further readjustment of muscular tension and the variations in metabolism between sitting and standing are of unusual interest."

Benedict and Carpenter (5) also made experiments to determine the difference between standing and sitting upon metabolism. Five experiments were made in which the subject sat from 2 to 4 hours and immediately afterwards stood for 2 to 3 hours, and the four factors of the grosser metabolism were measured.

"As might have been expected, there is an increase in practically all the experiments during the standing period, although singularly enough with the subject H.R.D., there was a lowered carbon-dioxide exhalation and water vaporization and a decreased oxygen absorption. On the other hand, there was a noticeable increase in the heat production." (5, p. 243.)

Thus the significance of the functional activity of the organism in the production of heat has been shown incidentally by the studies of metabolism. The more recent work in the respiration chamber has shown that such apparently trivial matters as writing, telephoning, moving about, even the sitting posture in contrast with the reclining position or the slight exertion of raising the hand to the mouth, may have a reasonable influence on heat production.

It must at least be admitted that the theory of Kassowitz as modified by Benedict's results is more in harmony with modern physiological and psychological teaching, placing, as it does, the emphasis upon function, and the actual facts as we find them rather than upon teleological reasons.

Involved in this theory is a more rational view of the way in which heat and energy are produced. According to this all forms of nutritive material, protein, sugar, fat, etc., are assimilated and always utilized for the synthesis of highly complex protoplasm molecules, and these, on account of their extreme chemical instability, are ready to be split up at the slightest impact; in this way energy is produced, and along with the dynamic effects heat also must be produced (22, p. 555).

We do know that protoplasm is built up by food and reserve material, for example, in the development of the organism from a tiny germ. But on the other hand we have no satisfactory proof that food, protein, fat, and sugar can be burned up in the living organism and changed into CO_2 and water without being first assimilated, that is being first utilized in the building up of living protoplasm.

Only one thing is certain, says Kassowitz (22, p. 575), namely, that neither the most accurate investigation of the finest histological structure of the muscle fiber, nor of the most industrious testing of its physiological functions in every direction by the most refined methods of experimentation have given even the most remote evidence of the transformation of heat into mechanical work in the human body.

Not only the muscles but also the glands and all the living parts of the body react to stimuli, produce combustion products and heat in a ratio proportional to the intensity of the stimuli and the amount of the functions produced. The oxidation does not occur in order that heat may be transformed into work, but because every stimulus and every disintegration of protoplasm occasioned by it involves *eo ipso* oxidation processes.

According to the view of Kassowitz heat is always an unavoidable by-product of all the functions that go on with the building up and breaking down of protoplasm. It is natural to presuppose that the share of the voluntary muscles in the processes of oxidation involved in the production of heat is very considerable. This has been shown also by numerous facts of experience. There is a reduction of the use of oxygen of more than ⅓ by the use of curare, of perhaps 30% by sleep; and experiments by Specht and von Löwy have shown that the increase of the elimination of carbon-dioxide due to cold does not occur until the trembling or shaking and muscle tension occur. Thus it is obvious that an animal who makes per minute more respirations and has per minute more pulse beats than another will also in a condition of rest expire more carbon-dioxide and correspondingly create more heat than the other. This is shown in experiments in the case of smaller animals in comparison to large ones belonging to the same species and in case of young animals not yet developed in comparison to older and developed animals of the same species.

Krogh (25, p. 415) has made a study of the capillaries and oxygen pressure in the muscle and the differences in the gas exchange between cold blooded and warm blooded animals and between warm blooded animals of different size, and finds that "The number of capillaries per square mm. of the transverse section of striated muscle appears to be a function of the intensity of the metabolism, being higher in small mammals than in larger forms:"

With the view of Camerer and his school, on the other hand, is very naturally associated a mechanical view of the production of heat. 1. Heat, according to them, is produced by the combustion of food in the body to supply the loss of heat by irradi-

ation from the surface of the body; the larger part of it for this purpose. 2. Heat is produced to be transformed into energy for work. Camerer takes also a mechanical view of the method by which power is furnished to the muscle machine. He maintains that the material which is burned up in the active muscle in some mechanical and not yet understood manner brings about a hardening and contraction of the muscle by which it overcomes resistance and does work.

The popular conception of this view is apt to be that heat and energy are produced in the human body in the same way as in engines that supply the power for mechanical work. In the carburetor of the automobile tiny drops of gasoline are picked up, mixed with air, and exploded in the engine, producing the power that is utilized.

The popular idea is expressed by a physician in a recent article on the physiology of the child as follows:

"In the muscular exertion of running, energy is liberated by the combustion of fuel in the muscles concerned in the movement, in exactly the same way that coal is consumed by an engine which is hauling a train."[1]

The fascinating simplicity of this mechanical theory may well make us suspicious that it does not tell the whole story. Let us look at the subject again from the point of view of stimulation and response. This calls attention at once to the fact that the human organism is not a clever machine for producing mechanical responses to definite mechanical changes in the fuel supply, but a complex living organism, continually subject to the changes of metabolism and in process of growth and development.

We do not have evidence of any such mechanical process in the human body. On the contrary, the fuel is built up into highly complex protoplasm molecules, and on occasion of stimulation these are broken down in the response, and heat is produced as a by-product. As Sherrington (33) has said:

"Food is not fuel in the ordinary sense. The fuel of the gas engine becomes no part of the fabric of the machine, and is not built into it, repairing wear and tear. But food entering the body seems to be in large measure vivified before its energy is taken. It is built up into the living fabric of the body. In that sense the creation of living matter from dead—a literal though not the technical heterogenesis—is going on today, and in each one of us."

In other words the food utilized by the body is assimilated, built up into protoplasm, and then broken down on occasion

[1] Pritchard, Eric: The physiology of the child. *Child Study*, 1909, Vol. 2, No. 1, p. 7.

of physiological stimulation. And heat is a by-product of these vital processes. Sherrington and a few other writers have expressed this view correctly. Hutchinson, in his "Dietetics," for example, expresses it as follows:

> "It would seem, indeed, to be to a large extent a matter of indifference to the cells of the *body* whether they draw their supplies of energy from proteid, albuminoids, carbohydrate, or fat, although probably they can get it more rapidly and easily from the three former than from the latter. We now know also that bodily heat is not a thing apart and requiring to be provided for by itself, but that it is an inevitable accompaniment of cell life. Life and heat are inseparable, and in fulfilling its other functions in the body a cell cannot help producing heat also. Heat, in fact, is a by-product of functional activity. Hence it is a matter of indifference as far as the cells of the body are concerned—not necessarily, be it remembered, as far as concerns the digestive organ—whether we feed a man on egg-white, gelatin, butter, or sugar, always supposing that these are supplied in the proportion of their dynamic equivalents."

The teleological explanation of the creation of heat in the living organism is not only inadequate and unfruitful, but it fails because it does not hold in the whole wide field of the organic world. It is true that it seems to have a justification in the case of warm blooded animals who maintain their body temperature approximately constant under the most varying external and internal conditions, although this is not strictly true. But in the case of cold blooded animals and in case of all plants, whose temperature differs only a fraction of a degree from that of their surroundings, the basis for the mechanical heat theory fails altogether; for these organisms have no means of retaining the heat created by their vital processes, and lack also the ability to increase their heat production in case of lower external temperature or to reduce it in the case of higher external temperature.

Conditions Determining the Greater Metabolism in Childhood[2]

To show more concretely the complexity of our problem we may now summarize the factors already mentioned and certain other conditions of the greater metabolism in children.

First is growth. The growing organism must have a greater amount of protein for the building up of new tissue, and thus growth is one factor. This, however, in itself, is not the prime factor in conditioning the greater metabolism. It has far less influence than is usually supposed. The child's rate of growth is very slow, the daily increase in the first month

[2] For the general factors affecting metabolism, see Benedict (3a).

of life being only about 1%and in the 12th month only .1 of one per cent of the body weight. However conflicting the theories mentioned, it should be noted that both agree that the metabolism required for growth is of secondary significance, that the greater metabolism is correlated in some way with the smallness of the child's body, and that by this fact is determined the greater relative amount of nutrition required.

Second. Again there is greater metabolism in the young because in the growing organism there is a greater amount of protoplasm and a smaller amount of metaplasm. By protoplasm is meant the living, assimilating, irritable protoplasm in which the processes of building up and breaking down, of metabolism, occur; and, on the other hand, by metaplasm, the parts which constitute the form of the organism and the reserve material. The latter are developed from the living protoplasm; and we should not think of them as by any means free from metabolism. Recent investigations by McCrudden have shown that in the bone, for example, processes of metabolism are continually going on, new bone is being built up, old bone is being broken down; and the bony structure, from a physiological point of view, is by no means static, but the seat of continuous processes of anabolism and katabolism. It is true, however, that metabolism in such tissue, which has been called metaplasm, goes on more slowly. Hence the relatively large amount of protoplasm in the child is significant; hence this preponderance of protoplasm in the young is the condition of a much more active metabolism quite apart from the size of the organism. The conclusion of Benedict and Talbot is in agreement with this view, as follows: "We believe that our evidence points strongly and conclusively to the fact that the active mass of protoplasmic tissue determines the fundamental metabolism. The absence as yet of a direct mathematical measure of the proportion of active protoplasmic tissue does not, we believe, in any wise affect the convincing nature of our evidence."

Third. The surface of the internal organs. The question naturally arises why may not the surface of the internal organs which represent largely the active protoplasm be significant and even the surface of the cell body as well. Pütter, in his remarkable investigations, has studied the active or functioning surface of the different bodily organs, and shown a relation between the functioning surface of an organ and the physiological work of the organ. In case of the kidneys, for example, it is not the mass or the weight of the kidneys that is significant, but the functioning surface. The urine secreted by the kidneys in the infant is relatively nearly two

and one-half times greater than that in the adult for the same unit of weight; and for different animals there are great relative differences; but for the active surface of the kidneys the relative functional value is practically the same for different animals.

His studies lead him to the conclusion that the metabolism per unit of the lung surface is a constant value and that this is the significant thing. This surface, however, does not grow proportionately to the body surface.

If we could take the active surface of an organ as a measure of its importance in the total metabolism of the body, then a new basis for the division of the quantitative functioning of the different organs would be obtained. In order to obtain comparable values the development of the surface of the capillary system would be determinative, out of which, Pütter (30, p. 213) holds, an inference in regard to the share of the separate organs in the exchange of the intermediary metabolic products could be obtained.

All this is in harmony with the conclusion made by Benedict that the amount of active protoplasm in the body is the prime condition in determining the amount of metabolism.

Of course we should consider the individual cells as well as the organs of the body. The studies of the cell have shown that in the young there is a relatively larger nucleus and in the adult with increasing age a greater amount of protoplasm. Minot indeed has made this increase of the protoplasm the essential condition in producing old age. This greater nucleus in the cells of the young is apparently an important factor, and may modify our view.

Fourth. The larger skin surface, probably in a minor degree, is a condition of the greater metabolism in the young, but not in the sense held by Camerer and Rubner. As Benedict and Talbot(11) put it:

"The basal metabolism as we have outlined above, can not in any wise be considered a direct function of the body-weight and the body-surface, and particularly has no relationship with body-surface on the basis of the law of cooling bodies."

In one way at least the larger skin surface in the child is sometimes a factor in conditioning greater metabolism from the fact that on the relatively larger skin surface of the child's body relatively more numerous skin vessels are contracted by the stimulus of cold, and also more skin muscle fibres are made to contract and produce heat than in the relatively less skin surface of the adult. This is only exceptionally a factor, since the skin of the child and especially that of the infant under

ordinary circumstances is seldom long exposed to low temperatures.

Fifth. Another condition of this greater metabolism is the fact that in a small organism the reflex arcs are shorter, and the fundamental processes of the heart, respiration, and the general movements of the body go on more rapidly.

As already noted the heart of the newborn child contracts about 130 times a minute; that of an adult, about 70 times per minute.

The investigations of a large number of children made by Benedict and Talbot show the correlation between the pulse rate and the metabolism. While, as yet, so far as I am aware, there is no direct experimental evidence to show that an individual who has constantly a high pulse rate, has a higher metabolism than an individual with a low pulse rate, it seems natural to make this inquiry, and as regards temporary changes in the pulse rate in the same individual Benedict and Talbot have furnished a large amount of evidence. Hence they make the following conclusion:

"This evidence of the relationship between the pulse rate and the metabolism, taken in connection with the evidence presented in previous sections of this book, gives an entirely new significance to the pulse-rate, since it may be considered as a very fair index of the metabolism. In other words, an infant having a pulse-rate of 120 at one period of the day and of 150 at another period has unquestionably a greater metabolism in the second period. There is no evidence, however, that a difference in the pulse-rate of any two infants necessarily indicates a proportional difference in the metabolism, even though the infants be of the same weight and age, and the periods of observation of the same length. But it is safe to say that variations in pulse-rate of an infant indicate a similar change in the metabolism." (11, p. 141)

"We may state, therefore, that whatever increases the pulse-rate also increases the katabolism, so that when the pulse-rate is elevated by the muscular activity incidental to restlessness, playfulness, laughing, or crying, or pathologically as in fever, we have every evidence that the katabolism is likewise increased and a larger proportion of food material or body substance is being consumed." (11, p. 141.)

Sixth. In young children, as everybody knows, the voluntary activity is much greater. This, then, is one of the chief causes of the greater metabolism in the young. It is perhaps the resultant of several of the other conditions, and this is of course in turn a result of the greater metabolism in the young; but, since, on the other hand, it conditions metabolism, it may well be mentioned as a special factor.

Seventh. The better general muscle tonus in the child and the more intense response to stimulation in the young. This is something we cannot explain, but the special characteristic

of youth is the ability to respond more intensely to stimulation. This is involved in what is called the better body tone, or it may be another way of referring to the same thing. In any case it involves greater metabolism. The conclusion of Benedict and Talbot is again in harmony with this position. "It is not to be inferred," they say, "that we believe that the increase in metabolism noted with increased pulse-rate is due exclusively to the mere mechanical work of circulation, as this is far from our belief. We especially wish to emphasize the fact that we look upon pulse-rate as an index of muscle or general tonus in the body and not as referring solely to the work of the heart muscles."

Eighth. One other condition, although indirectly determining metabolism, should not be neglected. No view is adequate which does not include the function which above all others characterizes man, namely, the function of attention and thought. Whether these mental processes are more intense in children than in adults, we do not know. If they should be found more intense in the adult that would be a factor on the other side against the conditions of greater metabolism in the young, or, if, as is not improbable, the processes of attention and the like are found to be more intense in the young, this would be another factor to be added to those already mentioned in accounting for the greater metabolism of the young. Specially significant is the fact that all these mental processes are colored by feeling, and the feelings and emotions are probably more intense or at least less controlled in the young. The recent investigations of the endocrine glands have shown their function undoubtedly correlated with the emotions, and no factor is more significant in regulating metabolism than the functioning of these glands, the thyroid gland especially stimulating to greater metabolism. Thus the statements made by some physiologists that the mental processes affect metabolism only slightly, are true only in a very narrow use of the words, i. e., so far as metabolism of the brain is concerned. In actual life the mental processes, so often tinged with emotion, are bound to be distinctly significant in stimulating to greater metabolism through the action of the thyroid and adrenal glands, and the correlated muscular activity. It is significant that the rather intense emotional life at about the age of 5 to 7 and again at puberty seems correlated with higher metabolism.

Recent investigators are just beginning to find concrete evidence of the way these mental processes affect metabolism. Benedict and Carpenter find that when a subject can by exercise of his will, relax his muscles, then the metabolism while at rest

is practically no greater than when quietly asleep; and Dodge, working in Benedict's laboratory, has recognized that all processes of attention involve increase in metabolism.

The relative importance of these different factors we cannot determine. With our present knowledge no better statement than that by Benedict can be made. He says: "The total katabolism of the infant is the resultant of two factors: First, the metabolism due to the internal activity incidental to circulation and respiration and the general muscle tonus of the body, i. e., maintenance metabolism; second, the metabolism due to the external muscular activity, which may vary from slight movements of the hand or fingers to violent movements incidental to severe crying." (11, p. 137.)

The inadequate and misleading character of the usual statements in regard to the greater metabolism in the young is obvious by a mere statement of the above facts. Any account of the condition of metabolism in child or adult must include at least the eight conditions here mentioned.

Practical Suggestions

The aim of this paper is not primarily to give concrete instructions in hygiene. A few practical points, however, are obviously emphasized from the point of view here presented, among them the following:

(1) This point of view emphasizes the great differences between the child and the adult. Only recently are physicians and hygienists beginning to recognize that physically the child is a very different creature from the adult. Only one book, that by a Russian author, has treated this subject with any degree of adequacy. Gundobin, in the book referred to, clearly enunciates this modern position as his standpoint. The child, he says, is sharply distinguished from the adult by the anatomical, physiological and chemical pecularities of his organism, and demands special study.

(2) This point of view emphasizes function as the essential condition of health in the organism. There is no such thing as a static or mechanical condition of health.

(3) The great difference between the child and the adult is the difference in functional activity. After the first period of development, culminating somewhere about the third year of life, the child's functional activity is greater than that of the adult. This is correlated with the more active response to stimulation and with higher metabolism.

(4) It suggests what in general the curve of learning probably is for the individual. Apparently Minot's view that the curve of learning is highest at birth, and constantly decreases

throughout life, or, as he puts it, the falling off in the ability to learn and the rate of growth and of senescence are correlated, is untenable. On the contrary, probably the curve of learning is correlated with the curve of metabolism. When that is discovered we may know what the curve of learning is also. Apparently it begins very low, the ability to learn increases up to the second or third year of life, then is very high until perhaps the sixth or seventh year of life, then falls off gradually until there is a decided increase at puberty, then falls off slowly with perhaps slight periodic variations until a point perhaps about 70, although varying greatly with the individual, and then falls off more sharply until the end of life.

(5) Our practical rules in regard to diet have been often erroneous because based on erroneous data. From the present point of view the important rules are the regulation of the amount of food taken according to the physiological age of the individual, and according to the work done by the individual; the man who does hard work requiring, as is well known, some 3,000 calories per day as against a minimum of perhaps 2,000 for the individual who does not work; and a child of six requiring twice as many calories as an adult for each kilogram of body weight or each square meter of body surface.

(6) It emphasizes certain practical points in regard to clothing. The practice of many parents, in muffling young children in clothing, especially when riding in a railway train or the like is the cause of grave discomfort. While the adult is inactive, the child is bound to be active, and the activity of the child, the excess of temperature likely to occur in the car, besides the greater functional activity of the child's organism, produce an amount of heat that must be in many cases torture. The crying and petulance of young children who are thus wrapped up in extra clothing is sufficient evidence in itself of their extreme discomfort.

(7) This point of view emphasizes certain practical suggestions in regard to exercise. The organism of the young child is well fitted for violent exercise for short periods. The heart is relatively small, the arteries relatively large. Cardiac disturbance as a result of violent exercise is quickly compensated for; and, while a child becomes quickly heated by the intensity of its functional activity, instinctively it rests after a short period of violent exercise, and then is ready for further exercise. On the contrary, exercises of endurance which give no opportunity for this cooling of the body after a short period

and which keep up the intense functional activity are liable to be injurious.

(8) Many erroneous and misleading statements have resulted from the commonly accepted view of the necessity for heat production as the main condition in determining metabolism. For example, in case of an individual fasting or on a hunger strike or the like, statements are usually made to the effect that the tissues are used up as fuel; first the superfluous tissues, fat and the like, are burned up, then the more essential bodily tissues; finally the nerve cells of the brain, the citadel of the body itself. On the contrary, the muscular activity of the individual is what destroys the tissues. Even before experimentation this would be fairly obvious merely from the observation of animals in the hibernal sleep and the like. In such cases life is preserved for a long period without serious destruction of tissues because bodily activity is reduced to a minimum.

(9) To increase one's metabolism the method of increasing the amount of nitrogenous food is a poor one. This will have little effect if one remains inactive. To increase the metabolism one must increase one's activity. As Stiles has well stated the case: "The change from fasting to feeding influences the metabolism much less than might be anticipated. It is true that a fasting animal will usually be found to have a low metabolism but this is because it is disposed to quiet. If it is given food, and remains as inactive as before, the increase in oxidation will be very moderate. It is not likely to exceed 20 per cent, whereas mild muscular activity will double the original quantity." (34, p. 337.)

Of course a child or an adult who has to live in a cold house does need an extra amount of food on a cold day, because he will perform an extra amount of work in trying to keep warm. If nothing else, he will shiver, a reflex having as its purpose the protection of the organism from cold. Nature permits one to loaf and starve, or work and eat, but in a cold environment the production of heat is compulsory. If one will not produce it by voluntary exercise of the muscles, one is forced to do so by exercise in the reflex activity of shivering.

While the conditions that determine the greater metabolism in childhood are complex, we can put the hygiene of the whole matter in a nutshell. Children need relatively more food than adults, not merely because their bodies are small, the body surface relatively large, and all the fundamental organic processes go on more rapidly, but also because their response to stimulation is more intense, the general muscle tonus is better, and the amount of protoplasm in their tissues relatively to the

metaplasm is greater, and also because they are normally more active. A child's business is two-fold: first, to grow; second, to play and work. One of the greatest handicaps to these prime functions of childhood is malnutrition. Recent studies have shown that this is widespread—among the poor due to lack of food, among the wealthy due often to lack of a proper regimen. The essential need is an abundant supply of suitable food, not a high protein diet, but a great variety with plenty of food and vegetables, and proper habits of eating and exercise.

BIBLIOGRAPHY

1. Atwater, W. O. Dietetics. *Encyclopedia Britannica.* Cambridge, 1910. Vol. 8.
2. Benedict, F. G. The influence of inanition on metabolism. Washington, 1907. 542 p.
3. ——. A study of prolonged fasting. Washington, Carnegie Institute, 1915. 416 p.

3a. ——. Factors affecting basal metabolism. *Jour. of Biol. Chem.,* 1915, Vol. 20, pp. 263-299.

4. ——. Human vitality and efficiency under prolonged restricted diet. Washington, Carnegie Institute, 1919. 701 p.
5. —— and Carpenter, T. M. The metabolism and energy transformations of healthy man during rest. Washington, Carnegie Institute, 1910. 255 p.
6. —— and Cathcart, E. P. Muscular work; a metabolic study with special reference to the efficiency of the human body as a machine. Washington, Carnegie Institute, 1913. 176 p.
7. —— and Homans, J. A respiration apparatus for determination of the carbon dioxide produced by small animals. *Amer. Jour. of Phys.,* 1911, Vol. 28, pp. 29-48.
8. —— and Joslin, E. P. A study of metabolism in severe diabetes. Washington, Carnegie Institute, 1912. 135 p.
9. —— and Muschhauser, H. Energy transformations during horizontal walking. Washington, Carnegie Institute, 1915. 100 p.
10. —— and Slack, E. P. A comparative study of temperature fluctuations in different parts of the human body. Washington, Carnegie Institute, 1911. 73 p.
11. —— and Talbot, F. B. The gaseous metabolism of infants, with special reference to its relation to pulse-rate and muscular activity. Washington, Carnegie Institute, 1914. 168 p.
12. Buchanan, Florence. The significance of the pulse rate in vertebrate animals. Smithsonian Institute Report, 1911, pp. 487-505.
13. Burnham, William H. Food and the feeding of school children. In *Monroe's Cyclopedia of Education.* N. Y., Macmillan, Vol. 2.
14. ——. The fundamental principle of hygiene. *Pedagogical Seminary,* 1918, Vol. 25, pp. 329-368.
15. Camerer, W. Das Energiegesetz in der menschlichen Physiologie. *Jahrbuch für Kinderheilkunde,* 1907, Vol. 16, pp. 129-187.
16. ——. Ernährung des Kindes. Das Buch vom Kinde. Leipzig, 1907. pp. 48-50.
17. DuBois, Eugene F. The respiration calorimeter in clinical medicine. Harvey Lectures, 1915-1916, pp. 101-124.

18. Emerson, William R. P. and Manny, Frank A. Weight and height in relation to malnutrition. Boston, Nutrition Clinics for Delicate Children, Pamphlet 26, 1920. 18 p.
19. Flexner, Simon. Epidemiology and recent epidemics. *Science,* 1919, Vol. 50, pp. 313-319.
20. Harris, J. A. and Benedict, F. G. A biometric study of basal metabolism in man. Carnegie Institution of Washington, Washington, 1919. 266 p.
21. Hutchinson, Robert. Food and the principles of dietetics. London, Arnold, 1900. 548 p.
22. Kassowitz, Max. Die Ursachen des grösseren Stoffverbrauches im Kindesalter. *Jahrbuch für Kinderheilkunde,* 1908, Vol. 17, pp. 551-588.
23. ——. Der grössere Stoffverbrauch des Kindes. *Zeit. f. Kinderheilkunde,* 1913, Vol. 6, pp. 240-252.
24. Krehl, L. and Soetbeer, F. Untersuchungen über die Wärmeökonomie der poikilothermen Wirbelthiere. *Archiv für d. gesamte Phys.,* 1899, Vol. 77, pp. 611-638.
25. Krogh, August. The number and distributions of capillaries in muscles with calculations of the oxygen pressure head necessary for supplying the tissue. *Journal of Phys.,* 1919, Vol. 52, pp. 409-415.
26. Lissauer, W. Ueber Oberflächenmessungen an Säuglingen und ihre Bedeutung für den Nahrungsbedarf. *Jahrb. f. Kinderheilkunde u. physische Erziehung.* 1903, Vol. 58, pp. 392-411.
27. Mitchell, David. Malnutrition and health education. *Pedagogical Seminary,* 1919, Vol. 26, pp. 1-26.
28. —— and Forbes, Harriet. Malnutrition and health education. *Pedagogical Seminary,* 1920, Vol. 27, pp. 36-66.
29. Paton, D. Noël. The nervous and chemical regulators of metabolism. London, Macmillan, 1913. 217 p.
30. Pütter, August. Aktive Oberfläche und Organfunktion. *Zeit. f. allgem. Phys.,* 1911, Vol. 12, pp. 125-214.
31. Roberts, Lydia. What is malnutrition? U. S. Dept. of Labor, Children's Bureau, 1919, Bureau Publication, No. 59. 20 p.
32. Rubner, Max. Das Wachstumsproblem und die Lebensdauer des Menschen und einiger Säugetiere vom energetischen Standpunkt aus betrachtet. *Archiv f. Hygiene,* 1908, Vol. 66. 153 p.
33. Sherrington, C. S. Physiology; its scope and method. *In* Strong, T. B. ed. Lectures on the method of science. 1906, pp. 59-80.
34. Stiles, P. G. Human physiology. Philadelphia, Saunders, 1916. 405 p.
35. Tredgold, A. F. Mental deficiency. N. Y., Wm. Wood & Co., 1914. pp. 291-295.
36. Vierordt, K. H. Anatomische, physiologische und physikalische Daten und Tabellen zum Gebrauche für Mediziner. Jena, Fischer, 1906. 616 p.

A MINIMUM SET OF TENTATIVE PHYSICAL STANDARDS FOR CHILDREN OF SCHOOL AGE

By G. B. Affleck, Professor of Hygiene, International Y. M. C. A. College, Springfield, Mass.

Introduction

It is a function of scientific procedure in any recognized field of human endeavor, not only to secure and verify accurate information, but also to determine the significance and relationships of ascertained facts; and, for purposes of application, to standardize both the facts themselves and the methods of their use.

Education, especially since it has become so little a perquisite of the home and increasingly a duty of the state, has felt the influence of material and commercial standards, and has realized the need for similar systematized methods that the thousands of children in the public schools might be "handled" with as little waste and friction as possible. The four-fold division advocated by Commenius has been somewhat modified into the kindergarten, elementary, secondary and higher systems, a device both rational and expedient. Within each of these larger groups come the finer divisions into years, grades, terms, semesters, quarters, etc., which represent a still finer classification of students into groups of somewhat uniform accomplishment if not of ability. It must in fairness be admitted that this very standardization in education has not in all cases proved of unmixed blessing or advantage. In many individual experiences gross injustice has been done because of the inflexibility of the "system." The seriousness of this defect is being increasingly recognized, however, and steps toward its reduction, or may one venture to hope, its elimination are being considered and actually introduced.

One of the most outstanding defects in educational procedure is the same in general as the criticism levelled against standardization in industry, viz., the individual human is not given due consideration. The attendant is not a part of the machine, but a human being with hopes and fears, likes and dislikes, ambitions and regrets, who is not belted to the countershaft but whose power and motive comes from within. Nor

can the pupil be regarded as so much raw material to be crowded through the educational machine in the hope of turning out a uniform product, up to "standard." Too often the attempt is made to force the student to conform to the schedule and program of the system, whereas the democratic ideal demands that the procedure be adapted to the pupil, that each be supplied with the opportunity, methods and materials best calculated to develop individual superiority subject only to limitations in ability. This, of course, presupposes that the actual conditions, powers and needs of each pupil be ascertained.

One way in which the correction of a too fixed and wrongly based standardization is being sought is by the recognition that grouping by the age or time basis is unsatisfactory and fails to give homogeneity within any of the present age or grade groups. The direction in which greatest progress has been made is that of attempting to ascertain concerning any individual pupil about whom a question as to standing may be raised, not the chronological age, not the grade standing, but rather the mental age or ability. This is based almost exclusively upon a variety of tests of intelligence, since from the very nature of mentality, intelligence is the factor which most readily lends itself to measurement by objective standards.

Another factor concerned with adjustment of the present unsatisfactory system of grading by chronological age or length of time in school is that of physical development. This is important both in its relation to mentality and on its own account.

The relationship between physique and mentality is one upon which great differences of opinion are still held. One can find experimental data supporting practically any attitude which may be suggseted.

Thus Gilbert(58, p. 39), Bagley(6, p. 205) and West(141) found little or no, or in some cases even negative correlation between bodily development and mental ability. Burgerstein (29, p. 38) and others have criticized the above finding on the basis that mentality was judged not by the standing of the pupils but by the estimates of the teachers.

On the other hand Pearson(104, p. 106), Porter(109, p.168), Roberts(116, p. 359), MacDonald(90, p. 1027), Smedley(127), Zirkle(149, p. 9), Pyle(112, p. 39), Boas(19), DeBusk(48, p. 90), Burgerstein(29, p. 39), Crampton(44), Hogue(72), Baldwin(7, p. 82) and Arnold(2, p. 36) are among those who are satisfied that a positive and close correlation exists.

The general practice is to begin the formal education of children at some stated age—in most countries at 6 years—but factors other than and more significant than chronological

age are beginning to be considered. To some of these, representing physical development, attention is called in the following pages.

Methods of judging success or progress in school life have been too largely based upon knowledge of subjects included in the prescribed curriculum, but with the new emphasis upon health, the condition of the pupil must be given prominent if not foremost consideration. There seems to be good evidence that at least 20% of the public school pupils are undernourished, and a larger proportion have physical defects the great majority of which are remedial. Military data indicate that many of the disqualifying defects might have been prevented or cured during school life.

It is well recognized that no single factor such as stature, weight, eruption of permanent teeth, development or organization of any muscle group, presence or absence of any secondary sexual characteristics, or in fact any known aspect of an individual may, by itself, be accepted as an infallible index of physiological development. Allowance for individual variations must be made no matter what test is being applied, but when such variations depart sufficiently from the selected standards, and especially when such variations in several tests are in the same direction from the standards, there is rather satisfactory evidence of abnormality, which may be either precocity or retardation.

Thus, should a pupil be found who shows consistently light weight for his age or height, retarded eruption of teeth, weak forearm muscles and poor coordinating power there is a concurrence of evidence of physiological subnormality, which surely deserves recognition in plans for that pupil's health and progress in school and home.

It is not assumed that each pupil's increase in any given measure will show the same regular upward movement as is indicated in the tables or standard; yet it is believed that in case of normal development each child would not differ widely from the corresponding figures. So, wherever possible from the original data, normal deviation has been computed giving the zones within which these deviations might be expected to fall. The practice is to regard any departure beyond these limits as deserving of special attention, especially should such deviation be in the direction of subnormality.

The actual time of the appearance or maturing of any change or quality in a complex organism such as the human body, is not referable to any mere temporal reckoning of the length of life, but is essentially one of development. So it is quite in accord with expectation that there cannot be any definitely

marked "time line" but rather a "time zone" within which any physiological transition may be expected to manifest itself. Boas(17, p. 187) has phrased this fact as follows:

> "The range of individual differences may be indicated by those ages within the limits of which one-half of all the individuals observed attain a certain physiological development."

or, as Boas has also summarized variability:

> "When we consider children of a certain age we may say that they will not all be in the same stage of development. Some will have reached a point just corresponding to their age, while others will be a little behind, and still others in advance of their age. We may assume that the difference between the stage of their development and that belonging to their exact age is due to accidental causes, so that just as many will be less developed as further developed than the average child of a particular age."

Agreeable to the principle enunciated above, the normal range of individual variations of a given age, for any single test, may be regarded as those values within which come the attainment of one-half of those observed. In practice this may be calculated by computing the median, middle value, a 50% line for the norm, the limits of normal variation will then be those values representing the middle point between this median value and the limits of the series either way, i. e., of the 25% and the 75% lines.

As in the case of mental age, certain milestones have been determined empirically as standards by which this physical progress may be judged.

Structure and function in the human body are so intimately interrelated that they should be separated only in thought and for purposes of convenience in treatment. The more important is function, but this is often difficult or impossible to test mechanically, and moreover, is frequently correlated with or based upon structures which are visible or superficial and so subject to examination, measurement, comparison, etc. In some cases structures are significant in themselves, e. g., the teeth, but in others they are but the physical basis or outward manifestation of functions which are in consequence judged and estimated on the basis of their associated structures, e. g., pubescence. On the other hand, there are certain powers or functions which may be measured as such, without prime attention to the structures involved which may condition their functional efficience, e. g., lung capacity or strength of grip.

With the primacy of function over structure definitely in mind, it is possible as a matter of classification to group the physical tests or examinations into two divisions, viz.:

1. Structural or Anatomical, those giving evidence of, e. g., size (height), mass (weight), number (teeth), significant external signs (pubic hair).

2. Functional or Physiological, those which test power directly in such particulars as, e. g., strength (forearm grip), respiratory power (lung capacity), muscular control (tapping).

Of the two foregoing groups of physical tests only a limited number are admittedly suitable for use in connection with public school education. The basis of selection of the tests advocated herein has been to include those which come within the following requirements:

1. They must be of interest and value from the standpoint of education and hygiene. This will eliminate from the accepted list many measurements which may have a high anthropological significance, e. g., cephalic index, facial angle, breadth of hand, color of eyes, etc.

2. They must be practicable from the standpoint of conditions existing or likely to exist in public school systems. This means in the main that the accepted tests be simple so as to require a minimum of skill, in taking and of expense by way of equipment, and that they do not make too serious a demand upon the time of teachers or pupils. In the present stage of conventional modesty there must be recognized certain limitations in the extent to which the exposure of the person of the pupils will be acceptable to parents or guardians.

It should be distinctly understood that the physical tests advocated may very properly and with advantage be taken as a part of the medical examination of the pupils, but must not in any sense be regarded as a substitute for the complete examination, which involves many important considerations not intended to be included in the brief list advocated.

In the standards submitted, which are based upon the best figures available and are computed by the "generalizing" method, the age represents that of the last birthday.

It must be reemphasized, however, that both the values assigned as norms and those limiting normality must be regarded as tentative. So, in case a child shows extreme variation, i. e., beyond the limits of normality as shown by the standard, in some detail but is within the limits in all other particulars, the question may very properly be raised as to whether normal variation in the detail concerned may not be wider than the figures thus far available have indicated. It is only by repeated checking of temporary standards against many further actual measurements that values deserving of final approval may be secured.

The purpose of this study is to make selections from the widely scattered and varying data derived from relevant investigations, and from these to attempt to establish a minimum list of tentative standards for physical growth and development in the various ages of school life, approximately the ages 6 to 16. It is hoped that such standards may prove of practical value to parents, teachers, physical directors, school nurses, and examining physicians; that they may stimulate interest in the subject; and encourage cooperation in further investigations and experiments with a view to modifying and correcting these tentative standards, of rejecting those which may prove impracticable, and of adding others which may appear significant.

Height

Skeletal growth as measured by height, apart from the variations due to posture, is virtually a bone measurement and appears to be almost entirely independent of unfavorable circumstances such as malnutrition. Among the studies bearing upon this are those of Jackson(75, p. 153) who finds that young albino rats held at constant body weight for considerable periods by under feeding show a normal skeletal growth accompanied by a striking failure of the musculature to increase, which usually at the ages concerned is making rapid gains. This skeletal increase during constant body weight appears to involve ligaments as well as cartillages and bones, and tends to proceed along the lines of normal development as indicated by decrease in water content and by the formation and union of various epiphyses.

Hall(62, Vol. 1, p. 19), after reviewing the work of many investigators, states:

> "Of all single measurements, height is the most valuable. It is easily taken, is relatively constant, and is not liable to much fluctuation. Along with weight it is the truest expression of the energy of growth, the best index of health, and gives a datum from which by the use of current norms and standards, many other data can be approximately inferred. It is, moreover, the most distinctly human dimension as man alone has attained a fully erect attitude."

Rusk(123, p. 25) is authority for another statement of a similar nature, claiming that of the various bodily measurements, height most faithfully indicates general physical development, being less dependent than weight upon variable individual differences. Height measurement indicates that from 6 to 9 years is a period of uniform and rapid development and that at nine irregularities begin to appear.

"There is at this age a retardation with girls, and with boys a more decided retardation occurs at 11 years of age. An acceleration of growth acccompanies the pubertal change, attaining its maximum with girls at 13 and with boys at 15. Girls are shorter than boys except during the years 11 to 14 when they are taller; this is due to the earlier onset of puberty of girls, giving them an accompanying advantage during these years."

Robertson(117, p. 552), basing his conclusions on studies on human subjects, concludes:

"The variability in stature is much less than the variability in weight from which we may infer that as a criterion of abnormalty, the measure of stature is more reliable than that of weight, while as a sensitive indication of the effects of environment or dietetic fluctuations, the measure of weight is to be preferred to that of stature."

By all means the most extensive and representative figures for height of school children are the Boas-Burk tables(31, p. 262), which are derived through merging by approved mathematical methods, the figures of Bowditch, Porter, Boas and others, and include the measurements of 45,151 boys and 43,298 girls in the cities of Boston, St. Louis, Milwaukee, Worcester and Oakland.

As was noted in the introduction, it is essential, in order to allow for individual variations, to provide a standard which includes a reasonable range, on either side of the values representing the average. The usual method of calculating this is by the determination of the quartiles, the 25% and the 75% lines, and regarding these as the limits of normal variation. This has been done for boys by Hastings(70), and since his norms, the 50% line, correspond very closely with the Boas-Burk values, they may be considered as supplementing the above standard tables.

TABLE I

HEIGHT, IN CENTIMETERS, EACH AGE 6 TO 16. (HASTINGS)

	Boys				Girls	
Age	Obs.	25%	50%	75%	Obs.	50%
6	410	107.00	110.67	114.34	352	107.16
7	544	112.19	115.69	119.19	514	114.95
8	565	117.17	121.31	124.85	531	120.16
9	546	122.08	125.86	129.64	534	126.17
10	498	126.79	130.95	135.11	517	131.29
11	660	130.97	134.90	138.83	522	135.16
12	559	135.61	140.29	144.97	526	142.03
13	515	140.28	145.09	149.90	534	148.53
14	435	145.29	151.02	156.75	534	153.17
15	324	151.37	158.18	164.99	459	156.79
16	218	158.26	163.73	169.20	355	157.93

The data for the completion of the table for girls is not at present available.

This table is intended to act as a guide in determining the height development of a pupil. Should his height vary from the norm (50% value) for his age, he may still be within normal limits provided he does not fall outside the extremes (the 25% and the 75% values). Should he vary more than these, however, there is then reason to consider his other aspects of development and find the reason for his deviation from the standard.

One of the most noteworthy facts, now thoroughly established, concerning growth in height is that it is rythmic rather than regular. Data have been collected relative to daily, seasonal and development as well as annual variations.

For recording height, the regulation instrument is the stadiometer, consisting of a horizontal base to which is attached a graduated vertical standard bearing at right angles a sliding arm. The pupil, with shoes removed stands on the base, heels together, knees pressed back, chest lifted, head pushed upward, and chin slightly drawn in. To aid in attaining a vertical position the pupil may be requested to stand so that his heels, sacral and dorsal spine, and back of head are touching the vertical rod. In the absence of this equipment, the heights required may be indicated on any convenient vertical wall or, better still, projecting corner or door post. A book or right-angled piece of cardboard may be suitably graduated for the sliding arm of the stadiometer.

Some observers advocate attempting to secure the normal or habitual standing posture of the pupil, but in the writer's experience, much more uniform results are obtained by having the pupil "stand tall" or "stretch up" as suggested above. This is one test in which encouragement of the pupil to do his best may be advised.

Weight

In weight, as in height, fluctuation rather than regularity is found to obtain. In general the weight development follows that in height, but is much more subject to influence by external forces, and much less determined by heredity. It is on account of this fact that weight is so frequently accepted as an index of condition by both physician and layman, and environment including work, rest, diet, recreation, etc., regulated to produce corrective results. According to Donoldson (52, pp. 49-50) the body from birth to maturity increases in height about 3.37 fold, but the weight increases 20 fold or more.

The fact that weight may be gained or lost readily renders it all the more valuable as an index of the immediate response

of the organism to its environment, as well as an indication of its functioning. Trainers and coaches depend largely upon the daily "weighing in" as a guide to the condition of their men, the commonly accepted standard being that, after the preliminary loss of weight common at the beginning of the season, the weight loss of the daily "work out" should be recovered within 24 hours, otherwise the candidate is approaching "edge" or "staleness" and should have his daily expenditure of energy reduced.

As in the case of height, the accepted standard for weight is the Boas-Burk table(31, p. 263) which shows the average American weight mathematically calculated from the data of about 68,000 children.

Again considering the importance of individual variation, the data worked out by Hastings(70) offer the most convenient reference. In case of weight he gives, in addition to the deviations for boys of different ages, the data from which those for girls may be approximated; there is submitted the following table:

TABLE II

WEIGHT, IN KILOS, FOR EACH AGE OF EACH SEX, 6 TO 16. (HASTINGS)

	Boys				Girls			
Age	Obs.	25%	50%	75%	Obs.	25% *	50%	75% *
6	410	18.06	19.37	20.68	352	17.62	18.50	19.38
7	544	20.30	21.30	22.30	514	19.78	20.70	21.62
8	565	21.28	23.14	25.00	531	21.22	22.17	23.14
9	546	23.11	25.07	27.03	534	23.22	24.90	26.58
10	498	25.74	27.85	29.96	517	25.61	27.16	28.71
11	660	27.49	29.86	32.23	522	27.22	29.00	30.78
12	559	30.14	32.98	35.14	526	31.26	33.06	34.86
13	515	32.15	35.60	39.15	534	35.80	37.94	40.08
14	435	35.00	39.73	44.46	534	39.47	42.92	46.37
15	324	39.93	46.95	53.97	459	42.86	46.71	50.56
16	218	47.60	52.90	58.20	355	46.09	50.38	53.91

* Estimated.

Weight is taken on platform, anthropometric scales of the Buffalo or Fairbanks types, either of which may be graduated in the metric or English units or in both. These scales are provided with two or three bars equipped with sliding, non-removable weights and with balance adjustments. Before each series of weighings, the scales should be balanced so the indicator swings freely between the two limiting bars. As a matter of convenience, the pupils should be weighed wearing ordinary indoor clothing with the exception of shoes which should be removed. On account of the fluctuations due to meals, time of day, etc., record should be made of the hour of the weighing.

Further note of time of year, recent health of pupil, and the like may also have value.

Height and Weight

No matter how favorable may be the inherited tendencies of a child, its environment has much to do with regard to the realization of its potentialities. Though environment cannot always alter the limitations set by inherited factors, it may prevent deteriorating influences from making very serious inroads on the growing individual or interfering with the best attainment of his developmental possibilities.

From the standpoint of hygiene, the most vital consideration of the child's life is nutrition. This, according to Manny(92 p. 123)

> "is not merely a matter of food, although that source of growth and energy is the central problem. Nutrition serves as an index of the result of the many strains and stresses that come from adenoids, enlarged tonsils, defective eyesight, and other effects of native disability and unhygienic living."

The standard most widely used for judging nutrition is known as the Dunfermline scale. It recognizes 4 groups, as follows:

1. "Excellent" represents the nutrition of a healthy child of good social standing.
2. "Good" is applied to those whose nutritive condition falls just short of "Excellent."
3. "Requiring supervision" describes children who are on the borderline of serious impairment.
4 "Requiring medical treatment" indicates that nutrition is seriously impaired.

In spite of the fact that these divisions do not seem to be very clearly defined, experience with the scale shows a surprisingly small variation among different examiners working on the same group of children.

Holt(73) has considered the question of some definite and measurable index of nutrition, and finds that weight in relation to age is not of greatest value, but that weight related to height is most significant. According to him the weight-height index would fix the child's status in nutrition,while annual increase in height would indicate his progress in growth, a question entirely different from that of nutrition.

The above conclusion is in accord with the suggestions of many investigators who have made similar attempts in the past.

Bowditch in 1877(22, p. 301) called attention to the importance of ascertaining the relation of height and weight in growing children, which might be expressed as a quotient.

Stephenson(128), bases results upon the figures of Bowditch for American and Anthropological Committee of the British Association, for English children. He has worked out a series of tables giving the standard weight, in pounds, for each inch in height, for boys and girls of each age from 6 to 18 years. These tables bear a resemblance to those prepared by Dr. Thomas D. Wood, published and so widely distributed by the United States Bureau of Education during the last few years.

The noted variations in the height-weight relation and in the relative development of different parts of the body, at each age, has raised the question of physical "types."

In 1910 De Giovanni(50, 51) published the results of his investigations on proportions and types. Montessori(97) in 1913 published extensive figures concerning human proportions and laid great emphasis upon the relation of length of trunk to that of limbs. Bryant(26, 27) stressed the importance of a knowledge and appreciation of the proportions of the trunk in relation to efficiency.

Goldthwaite(60) has given the most complete description of the neutral, the carnivorous or "lean" type and the herbivorous or "stout" type. His claim is that on the basis of the general proportions of the trunk may be inferred many other significant details of structure and function, such as length of intestine, shape and number of vertebrae and ribs, shape of stomach and appendix, etc. In addition to these non-visible features he shows the correlation between type, and quality of skin, pilosity, shape of feet, and other important organs. But most important of all is the demonstrated relation of type to health and disease, to occupation, and to biological principles of the development of the race.

Lewis(85) has made a study of adolescents on the basis of structural types and finds a decided preponderance of the carnivorous or "lanky" type, while the herbivorous exceeds the neutral type which constitutes only about 12% of the entire group examined. This shows a strong tendency towards the decided types and is due, Bryant claims(28), to diet, the key to the control of type and consequently to the diseases to which each type is liable.

The significance of these types from the standpoints of health, interests, capabilities and education is doubtless great, but the details of the proportions which would throw an individual of a given sex and at a given age out of the neutral and into the "stout" or the "lean" groups have not been so determined as to be generally accepted.

Taylor(132) has grouped boys into 5 rather than 3 types and has given the figures distinguishing the groups from each other.

Using height as the standard, he relates other measurements to it and only incidentally compares the measurements as a group with age.

Lowman(86, pp. 693-5) has used the material outlined by Goldthwaite and added from his own findings, giving a popular and significant outline of types and their features.

Emerson(54a), as the result of his nutrition clinics in New York, Boston and other cities is satisfied that at least 20% of the pupils in attendance at the public schools are under nourished. In order to offer an objective standard by which nutrition may be readily judged, he has published a height-weight table and has given the variations from the standard regarded as indicative of under nourishment. This table is adapted from the figures given by Holt(73) for the younger children and from the Boas-Burk tables for pupils of school age. Since the present interest is with the latter group only, his table is quoted in part.

TABLE III

EMERSON'S NUTRITION STANDARDS

Height Inches	Boys			Girls		
	Aver. Wt. for Ht. Lbs.	7% Under Wt. Lbs.	10% Under Wt. Lbs.	Aver. Wt. for Ht. Ins.	7% Under Wt. Lbs.	10% Under Wt. Lbs.
40	38.1	35.4	34.3	37.4	34.8	33.7
41	39.8	37.0	35.8	39.2	36.6	35.3
42	41.7	38.8	37.5	41.2	28.3	37.1
43	43.5	40.5	39.2	43.1	40.1	38.8
44	45.4	42.2	40.9	44.8	41.7	40.3
45	47.1	43.8	42.2	46.3	43.1	41.7
46	49.5	46.0	44.6	48.5	54.1	43.7
47	51.4	47.8	46.3	50.9	47.3	45.8
48	53.0	49.3	47.7	53.3	49.6	48.0
49	55.4	51.5	49.9	55.3	51.9	50.2
50	59.6	55.4	53.6	58.3	54.2	52.5
51	62.5	58.1	56.3	61.1	56.8	55.0
52	65.8	61.1	59.2	63.8	59.3	57.4
53	68.9	64.1	62.0	66.8	62.1	60.1
54	72.0	67.0	64.8	70.3	65.4	63.3
55	75.4	70.1	67.9	74.5	69.3	67.1
56	79.2	73.7	71.3	78.4	72.9	70.6
57	82.2	77.0	74.5	82.5	75.7	74.3
58	87.0	80.9	78.3	86.6	80.5	77.9
59	91.1	84.7	82.0	91.1	84.7	82.0
60	95.2	88.5	85.7	96.7	89.9	87.0
61	99.3	92.3	89.4	102.5	95.3	92.2
62	103.8	96.5	93.4	110.5	102.7	99.4
63	108.0	100.4	97.2	118.0	109.7	106.2
64	114.7	106.7	103.2	123.0	114.4	110.7
65	121.8	113.3	109.6	130.0	120.9	117.0
66	127.8	118.9	115.0	137.0	127.4	123.3
67	132.6	123.3	119.3	143.0	133.0	128.7
68	138.9	129.2	125.0	146.9	136.6	132.2

In discussing the above table, Emerson states(54a) that:

"All children who are habitually as much as seven per cent under weight for their height are malnourished. This degree of under weight means that the children are at least *a whole year below the normal standard which they ought to have attained.* They are not only under weight, but under their normal height also."

Emerson does not entirely disregard height in relation to age. A letter from his clinic says:

"We make it a rule to use the weight-height ratio for the purpose of selecting that very large group of malnourished children most urgently in need of attention, and then depend upon individual diagnosis to identify borderline cases not reached by the general rule. Naturally, any child who is clearly below the height and weight measurements usual at his age, receives special consideration, even though his ratio may be normal. In such a case an actual condition of good health must be proved before it is fair to assume that he is doing as well as is possible for him to do."

This latter statement is important from the fact that arrest of height growth due to under nutrition is rapidly overcome when such stunted children are placed under proper conditions, for they soon prove that they have a capacity for growth in both height and weight not heretofore realized.

Osborne and Mendel(100, 101, 102) have given ample experimental evidence of the remarkable power of young animals to resume growth, at an accelerated rate, after long-continued retardation due to unfavorable conditions, e. g., unsuitable diet.

Retan(114) has given evidence, in graphic form, of the unreliability of using weight in relation to age as a standard of nutrition, and is satisfied that the weight-height relation affords a suitable index.

Teeth

Among the reasons for special attention to the time of eruption of permanent teeth, as an index of physical development, maye be noted the following:

1. The first permanent tooth to erupt is the first molar, which is the sixth tooth from the middle line of the face, and makes its appearance normally by the time the child is six years of age. It is, in consequence, sometimes called the six-year molar, and, on account of the fact that it erupts about the time the child enters school, it is a most convenient sign post of physical development. All too frequently, this tooth is regarded by child, teacher and parents as one of the temporary set, and since it erupts when the milk teeth are about to be shed, its

life is supposed to be of but short duration, and in consequence it seldom receives the attention and care which its position in the arch demands.

The statement of Angle(1, p. 302) is that in function and influence some teeth are of greater importance than others, the most important of all being the first permanent molars for the following reasons:

(1) "They are the largest and firmest in their attachments.
(2) "They have the most important location in the arches.
(3) "Their length determines the separation of jaws, and length of bite, thus contributing to facial proportions.
(4) "They are first in position, and influence other tooth positions.
(5) "They are most constant in time of eruption, and in the assumption of normal positions."

2 Tooth eruption continues more or less regularly throughout school life, thus affording a practically constant indication of the rate of physical development in the individual pupil.

3. There is not required for the recording of the eruption of the teeth any elaborate equipment, nor is there great likelihood of error because of personal equation. Certain teeth either are or are not present, and if present may be seen, identified and counted. This test is therefore one of the most definite of any in use or in fact conceivable.

4. The teeth have a peculiar relation to nutrition. On the one hand the time of their eruption, their shape, condition, etc., is an indication of the pupil's nourishment up to the time of examination; and, on the other hand, the number, condition and arrangement with regard to occlusion is very definitely related to food mastication and consequently to subsequent digestion and assimilation. This latter aspect has received recent emphasis from the number of rejections of recruits on account of failure to measure up to the Government requirement in this particular.

5. There seems to be adequate evidence of the value of the age at which teeth erupt as a factor indicating development. Mackenzie(91, pp. 255-65) states that the number of teeth present at any given age is of prime importance as a test of development. Bean(12, p. 612), concludes that:

"the teeth are more convenient and more exact as a means of determining the physiological standard than stature or weight or growth of bones or secondary sexual characteristics, etc., and they may be of greater value than any other means that can be utilized."

Beik(14, p. 203), after careful investigation, is entirely satisfied that:

"The state of advancement reached in dentition is a good indication of the stage of progress which a child has reached in its total physical development."

Bean(12, p. 601) has prepared a standard table for norms of teeth eruption of American children, but since he has not offered figures indicating normal variability, the table prepared by Woodrow(145, p. 103) which agrees closely with Bean's is selected. These figures are based mainly on the work of James and Pitts(76) who investigated 4,850 English children of school age.

TABLE IV

SHOWING THE AGES AT WHICH 50%, 25%, AND 75% OF CHILDREN NORMALLY HAVE ERUPTED THE TEETH INDICATED. (WOODROW)

Name of Tooth	Present in 50% of Children	Present in 25% of Children	Present in 75% of Children
Lower First Molar	6 Yrs. 0 Mos.	5 Yrs. 6 Mos.	6 Yrs. 6 Mos.
Upper First Molar	6 " 3 "	5 " 9 "	6 " 6 "
Lower Median Incisor	6 " 6 "	6 " 0 "	7 " 0 "
Upper Median Incisor	7 " 6 "	7 " 0 "	8 " 3 "
Lower Lateral Incisor	7 " 6 "	7 " 0 "	8 " 6 "
Upper Lateral Incisor	8 " 6 "	8 " 0 "	9 " 3 "
Upper First Premolar	10 " 0 "	8 " 9 "	10 " 9 "
Lower First Premolar	10 " 6 "	9 " 6 "	11 " 9 "
Lower Canines	10 " 6 "	9 " 9 "	12 " 3 "
Upper Second Premolars	11 " 0 "	9 " 9 "	12 " 0 "
Lower Second Premolars	11 " 6 "	10 " 3 "	12 " 6 "
Upper Canines	11 " 9 "	10 " 9 "	12 " 9 "
Lower Second Molars	11 " 9 "	10 " 9 "	14 " 0 "
Upper Second Molars	12 " 6 "	11 " 6 "	14 " 3 "
Third Molars	14th to 24th Year		

The range in the above table is sufficiently wide to allow not only for variation due to sex but also for those arising from other normal influences.

Despite the fact that several authorities, of whom some have been quoted, are positive as to the uniformity of the age of tooth eruption, it seems necessary to add that, as in the case of other developmental aspects, undue emphasis must not be placed upon this single index by itself. So many are the factors which may influence the time of eruption that a too rigid application of this one standard, without relation to others, might easily result in entirely erroneous conclusions. This is particularly true with regard to those areas of the dental arch subject to the greatest variation, viz., the region of the upper lateral incisors, the lower second bicuspids, and the wisdom teeth or third molars.

Motor Development

One of the most significant of all possible tests would be one showing the rate of progress in neuro-muscular coordination. Experimenters have virtually all come to the adoption of the speed of tapping as the most representative of the practicable tests of motor development. It is known that at birth the child has control of but a few muscle groups—those connected with sucking and grasping being the conspicuous exceptions. With the growth and elaboration of the nervous system comes that coordination of the neuro-muscular mechanism so well traced by Burk(30).

Hall(62, p. 142) regards "the greatest number of taps that can be made in a given brief time interval as an important determination for the development of accessory muscular control" and as a "very important measure as a factor of motor ability."

The complete laboratory outfit is rather elaborate, consisting of the tapping board, 50 x 10 cm., with brass plates 10 cm. square on either end; tapping stylus with flexible connecting wire; kymograph with its essential accompaniments; and a stop watch. This may be much simplified by the substitution of an electric counter which will record the number of taps as accurately as the kymograph.

Franz, however, is sponsor for a method of testing motor development which does not involve expenditure for equipment. He explains it somewhat as follows(56, pp. 45-46): A very simple and inexpensive method of testing this type of voluntary control is to provide the pupil with paper and pencil, and have him make a series of dots as rapidly as possible for the required interval of time. The time selected is frequently 30 seconds and may be kept by a stop watch or, for practical purposes, by a watch or clock equipped with a hand recording seconds.

The technique of taking the test is simple. Seat the pupil in a chair of suitable height with his side (right then left) towards the desk or table, so that the forearm will rest comfortably upon the support. The tapping is done by a movement from the wrist with the pencil held vertically; it begins and ends on signal and is continued for 30 seconds. Record is made of the performance of the right hand, then of the left.

Experimental data are not abundant upon which to base even tentative norms. The results obtained by Smedley(127, p. 41) and by Pyle(113, p. 25) constitute the most extensive and are given below.

TABLE V

RATE OF TAPPING, 30 SECONDS, BOYS. (SMEDLEY AND PYLE)

Ages	Smedley			Pyle		
	Obs.	Right	Left	Obs.	Right	Left
6	..	...	...	62	121	107
7	..	...	...	61	129	111
8	31	147	117	76	136	111
9	60	151	127	76	144	123
10	47	161	132	70	152	131
11	49	169	141	84	163	136
12	44	170	145	74	168	141
13	50	184	156	82	175	150
14	40	184	155	75	177	154
15	37	191	169	85	188	166
16	21	196	170	51	190	168

TABLE VI

RATE OF TAPPING, 30 SECONDS, GIRLS. (SMEDLEY AND PYLE)

Ages	Smedley			Pyle		
	Obs.	Right	Left	Obs.	Right	Left
6	..	...	...	66	121	103
7	..	...	...	59	132	112
8	31	146	117	63	135	118
9	44	149	118	70	148	128
10	48	157	129	76	154	133
11	48	169	139	75	163	141
12	50	169	140	86	169	148
13	45	178	153	93	172	151
14	67	181	157	63	183	158
15	48	181	159	94	185	159
16	50	187	167	94	187	163

NOTE.—In Tables 13 and 14 the number of cases is not exact for Pyle's observations, since he had not always the same number for each hand; those given are for the right hand test.

In comparing the figures of Smedley and Pyle as given above it will be noticed that Smedley does not give the data for the ages 6 and 7; that Smedley's figures are higher than Pyle's except, in the main, those for girls where in some cases Pyle's results are greater; and that the number of cases on which Pyle's norms are based is greater than Smedley's.

Both investigator's, however, report less than 100 cases in each age so that it would appear that these norms are based on data insufficient to justify their final acceptance. Much further work should be done in this test not only that norms

may be established but also that the range of deviation may be secured and thus the zones of normality determined.

Lung Capacity

The terms lung capacity, breathing capacity and vital capacity have been used to designate the volumetric difference between the lung content at forced inspiration and at forced expiration. It might with more propriety be termed differential lung capacity or respiratory capacity, since even after forced expiration, the lungs are by no means collapsed but contain a residuum of air roughly estimated for the adult at 1,640 cubic centimeters (100 cubic inches).

This test is of exceptional value in that it indicates both development and functional power. Not only is there given an idea of the size of the thoracic cavity but more important still of the control or mobility of the chest. Chest girth is sometimes taken as an index of lung capacity. Military requirements are frequently based on a stated expansion for a given height. This means that the difference between the chest girth fully expanded and forcibly deflated must measure a certain number of inches or centimeters for each respective inch or centimeter of total stature.

All tape and caliper chest measures, however, are partial in that they cannot record the enlargement of the thorax along the vertical axis, produced by the movement of the diaphragm, the chief muscle of respiration. These external measures are of great significance from the standpoint of diagnosis, but involve the stripping of the child to the waist, a procedure not yet common except in medical examinations.

But the volumetric displacement recorded by the wet spirometer, includes the results of all the factors contributing to the change in intra-thoracic capacity, and in consequence from the standpoint of a functional test is much superior to any measurement which may be made upon the surface.

In making this test, the pupil is asked to inhale as deeply as possible, take the mouthpiece in his mouth and exhale steadily and continuously through it into the instrument, forcing out of the lungs as much air as possible. Record the reading of the indicator at the highest point of each of the two or three trials allowed and credit the pupil with the highest figure secured. In restoring the spirometer to its initial starting position, care should be taken to remove the stopper and to press the inverted cylinder down steadily but *slowly* to its original position, replacing the stopper. Pupils should be advised to grasp the mouth piece firmly with the lips, that no air escape around it and so lower the record. Exhalation should be

steady and not forced except during the latter part. Hygienic precautions in connection with assuring a sanitary condition of the mouth pieces demand that either the glass mouth pieces be thoroughly sterilized after use or, preferably, that wooden or paper mouth pieces be provided and discarded after use by one pupil; the expense is negligible. If necessary, pupils may be allowed to occlude the nostrils by pinching the nose between thumb and finger.

The norms and deviations from the standards are worked out in detail for boys by Hastings who also gives the figures from which those for the girls may be estimated approximately.

TABLE VII

LUNG CAPACITY, IN CUBIC CENTIMETERS, FOR EACH AGE (HASTINGS)

	Boys			Girls		
Age	25%	50%	75%	25% *	50%	75% *
6	560	830	1,000	580	710	840
7	810	990	1,170	710	830	950
8	950	1,150	1,350	830	990	1,150
9	1,140	1,230	1,520	980	1,140	1,300
10	1,250	1,480	1,520	1,130	1,270	1,510
11	1,450	1,660	1,870	1,140	1,350	1,560
12	1,610	1,830	2,050	1,300	1,540	1,780
13	1,770	2,030	2,290	1,560	1,730	1,900
14	1,950	2,300	2,650	1,620	1,850	2,080
15	2,210	2,640	3,070	1,720	2,020	2,300
16	2,640	3,140	3,640	1,880	2,140	2,380

Approximated

FOREARM STRENGTH

The finger flexors of the forearm, those used in closing the fingers as in giving a grip, are probably the most representative group of muscles in the young since they are in almost constant use in the routine of daily life. No matter at what employment or amusemnet one may be engaged there is necessarily much holding, handling, grasping, etc., which brings into functional activity this muscle group. Moreover, these muscles are of fair size, thereby giving a much more reliable index of muscular power than would a smaller group such as the flexors of a single finger which are often used in ergograph tests. According to Meyers(98) the child is born with an automatic grasping mechanism which "goes off" when stimulus is applied to the proper place, so that practice in co-ordinating the muscles involved is begun much earlier than in others producing movements of equal complexity. The actual taking of the test is comparatively simple, and with the adjustable Smedley dynamometer is reasonably accurate.

Measurement in millimeters, is first taken from the point where the pupil's thumb joins the hand, to the tips of the fingers. The manuometer is adjusted, by whirling the inner stirrup until the scale on the outer stirrup indicates one-half the distance above secured. Record this distance and set the clutch to prevent twisting of the inner stirrup during the test. Before each test set the indicator on the dial at zero. Have the pupil exert maximum grip, grasping the inner stirrup at the centre rather than toward either side. See that no part of the instrument touches any object other than the hand gripping it. Test the hands alternately, right and left, two or three times each, and select for permanent record the best performance for each hand.

TABLE VIII

STANDARDS OF FOREARM STRENGTH IN KILOS. (HASTINGS)

Boys

		Right Hand			Left Hand		
Age	Obs.	25%	50%	75%	25%	50%	75%
6	410	5.08	6.98	8.88	3.90	5.70	7.50
7	544	7.59	9.18	10.77	6.62	8.53	10.44
8	565	8.66	10.63	12.00	7.99	9.53	11.07
9	546	10.94	13.14	15.34	9.83	11.57	13.71
10	498	12.24	14.74	17.24	11.73	14.05	16.39
11	660	15.64	18.02	20.40	13.81	16.11	18.41
12	559	16.99	19.68	22.37	15.54	18.44	21.34
13	515	18.90	22.59	26.28	17.76	20.49	23.22
14	435	21.25	25.37	29.19	18.91	23.05	29.19
15	324	22.61	28.85	35.09	20.11	24.68	29.25
16	218	25.66	33.31	40.96	22.76	29.64	36.52

TABLE IX

STANDARDS OF FOREARM STRENGTH IN KILOS. (HASTINGS)

Girls

		Right Hand			Left Hand		
Age	Obs.	25% *	50%	75% *	25% *	50%	75% *
6	183	4.27	5.17	6.07	4.13	4.83	5.53
7	514	5.58	7.48	9.38	4.80	6.60	8.40
8	521	7.96	9.26	10.56	7.60	8.81	10.01
9	534	8.26	10.06	11.86	7.98	9.68	11.38
10	517	10.78	12.98	15.18	9.73	11.63	13.33
11	522	12.01	14.11	16.31	12.52	14.42	16.32
12	526	13.74	16.04	18.34	12.53	14.55	17.95
13	534	15.82	18.52	21.22	15.06	17.66	20.26
14	534	17.93	21.73	25.53	16.31	19.51	22.71
15	459	20.62	24.44	28.24	19.64	22.94	26.24
16	355	20.03	24.13	28.23	18.95	22.95	26.95

* Approximated.

Pubescence

As a result of comparatively recent scientific study of individual human development, especially from the genetic point of view, there has arisen an exceptional interest in the significance of the truly remarkable transformations, both physical and mental, which are related to pubescence.

Hall(62, p. 128) briefly summarizes the relation of education to adolescence as follows:

> "It is the age of reconstruction, when new determinants come to the front and also the point of departure for new lines of development. It is the age too when, if ever, previous tendencies to abnormality may be overcome both by nature and by treatment. The law of nascent periods or the age curve of growth of each organ or faculty, is one of the first desiderata of genetic psychology; how to apply it, by what means and to what degree to stimulate each part in its stage of most and least rapid growth, and how to apportion training of mind and body between developing the powers that excel to a degree of specialized culture that corresponds to their hereditary possibilities, or educating the weakest parts and powers in order to improve proportion and symmetry, is one of the chief problems of individual pedagogy."

The original and significant work of Crampton(44) has established and to a degree popularized a method for determining from external signs the progress of this notable aspect of Physiological development, and has compared it with chronological age.

This marked transition from the asexual to the sexual life occurs at various periods with different individuals, usually between 12 and 15 years of age, but whenever it does develop the changes are profound. Crampton(45, p. 228) thus describes it: "In the short space of 6 months the child becomes a man or woman, and the process is fraught with the dangers and turmoil of a new birth. There is an outburst of physical growth, 4 or 5 inches are added to the height, 30 or 40 pounds to the weight, and the strength may be doubled in a short space of time."

The relationship of this physiological change to age of boys, as ascertained by Crampton from the examination of 3,835 boys in New York City high schools is given as follows(41, p. 232):

TABLE X

PERCENTAGE OF EACH AGE IN EACH PHYSIOLOGICAL GROUP

Age in Years	Physiological Age Groups		
	Immature	Maturing	Mature
12.50 to 13.00	69%	25%	6%
13.00 to 13.50	55%	26%	18%
13.50 to 14.00	41%	28%	31%
14.00 to 14.50	26%	28%	46%
14.50 to 15.00	15%	24%	60%
15.00 to 15.50	9%	20%	70%
15.50 to 16.00	5%	10%	85%
16.00 to 16.50	2%	4%	93%

Dr. Wm. Burdick, Director of the Public Athletic League of Baltimore, has had observations made on girls, using as the index of pubescence, subcutaneous fat, axillary hair, appearance of breasts, and distinction between waist and hips, together with the personal statement of the girls as to the time of their development.

Part of the results of his studies may be found in the accompanying table, which is based on examinations by Dr. Mary A. Hodge, of more than 3,000 girls. The figures refer to the relationship of pubescence to age and include the ages 6 to 16 to coincide with the general ages considered in this treatment.

Crampton(41, pp. 232-4) has shown the marked relationship of the pubertal development of boys, ages 12 to 16, to height, weight, strength, etc., and has established the significance of this physiological functional development.

Educators have not realized to the full the importance of physiological age, especially in its bearing upon mental and social development. This lack of appreciation is evidenced by the fact that during the dozen years since Crampton made his masterly and widely circulated presentation of its claims, there are comparatively few educational institutions into which classification on this basis has been introduced.

Among the difficulties most frequently urged against the introduction of this basis of classification, may be noted the following: For half or more of the school life of the child, this basis of grouping has no significance, since it does not apply until signs of maturity are manifested.

The practical problem of continuous regrouping during more than 5 years, required for the entire mass of students to pass from the immature to the adolescent stage, seems to be more than the average principal or superintendent is willing to undertake. Still, it has been done. Principal Louis Marks, Public School No. 54, Manhattan, New York City, writes under date of May 3, 1920:

TABLE XI

MATURITY OF GIRLS AROUND BALTIMORE

	Prepubescent		Pubescent		Adolescent	
Age	Obs.	%	Obs.	%	Obs.	%
6	14	100.0	..	....	...	....
6.5	23	100.0	..	....	...	....
7	33	100.0	..	....	...	....
7.5	46	100.0	..	....	...	....
8	60	100.0	..	....	...	....
8.5	54	100.0	..	....	...	....
9	79	100.0	..	....	...	....
9.5	108	99.0	1	1.0	...	....
10	112	100.0	0	0.0	...	....
10.5	127	96.2	4	3.0	1	0.7
11	114	92.6	9	7.3	0	0.0
11.5	103	78.6	25	19.0	3	2.2
12	90	66.1	39	28.6	7	5.1
12.5	88	57.5	45	29.4	20	13.0
13	61	37.8	61	37.8	39	24.2
13.5	38	23.7	49	30.6	73	45.6
14	24	13.4	51	28.7	103	57.8
14.5	7	4.7	29	19.7	111	75.5
15	4	2.7	22	15.1	119	82.0
15.5	2	1.3	11	7.1	141	91.4
16	2	1.4	6	4.2	133	94.3
16.5	0	0.0	4	3.0	126	96.9
17	1	1.1	..	....	98	97.9
17.5	1	1.1	..	....	87	98.8
18	1	0.1	..	....	658	99.7
Total	1202		356		1719	
		Grand Total.....				3277

"In answer to your request of April 28th, I beg to state that we have continued the system of classification of pupils on the basis of Dr. Crampton's Physiological Age ever since it was introduced some seven years ago. We have every reason for maintaining this grouping of the boys in the upper grades of our school. The teachers find this arrangement far more helpful than the old promiscuous grouping. The emotional and social factors are the predominant reasons for continuing this plan."

In physical contests such as athletics, in playgrounds, public and Sunday School athletic leagues, etc., a division of contestants upon the physiological age basis, has been found to work out satisfactorily, subdivisions on some other basis, e. g., weight being made within each of these large groups when necessary.

An attempt has been made to correlate the three physiological groups of the ages 12 to 16 with the 25%, 50% and 75% values of the same chronological age. Since Crampton's tables of height, weight and grip show a distribution within each age,

corresponding in a measure with the percentile values, some are satisfied that the percentile grouping within each chronological age is adequate. Foster(55, p. 87), speaking of classes grouped on a physiological basis, rather supports this view with regard to height.

"There is some overlapping of height in the different grades of pubescence, but the relationship is so close between height and pubescence that it might seem to a person who had a view of the different classes at the same time as if the classification had been made according to height. All the smallest boys are found in the first grades, and all the largest in the last grades, although in the physical examination not the slightest attention was paid to the boy's weight when the degree of pubescence was noted."

From the biological point of view, however, the tendency seems to be to regard sexual development as one, and in many respects the most important, of the physical manifestations in man of the great fundamental vital principle characterizing all organisms; the common factor of which growth of all the structures and maturing of all the functions are but different aspects.

Of the various physical sign posts considered, pubescence seems to be related more definitely than any of the others, to the mental and social aspects of the pupil's development, so has additional claim to consideration, but this phase is outside the scope of the present inquiry.

BIBLIOGRAPHY

1. Angle, E. H. Treatment of malocclusion of the teeth. Philadelphia, S. S. White Dental Mfg. Co., 1907. 628 p.
2. Arnold, F. Weights and school progress. *Psychol. Clinic,* 1916, Vol. 10, pp. 33-39.
3. Ayres, L. P. Laggards in our schools. New York, Charities Pub. Co., 1909. 236 p.
4. ——. The effect of physical defects on school progress. *Psych. Clinic,* 1909, Vol. 3, pp. 71-77.
5. ——. The relation between entering age and subsequent progress among school children. *Education,* 1912, Vol. 32, pp. 325-333.
6. Bagley, W. C. On the correlation of mental and motor ability in school children. *Amer. Jour. of Psychol.,* 1901, Vol. 12, pp. 193-205.
7. Baldwin, B. T. Physical growth and school progress. Bureau of Education Bul., 1914, No. 10. 215 p.
8. ——. Standards and tests for the measurement of the efficiency of schools and school systems. Fifteenth Year Book, National Soc. for the Study of Educ., 1916, Part 1. 172 p.

8a. ——. A measuring scale for physical growth and physiological age. Fifteenth Yearbook, Soc'y. for Sci. Study of Education, 1916, Part 1, 22 pp.

9. Barach, J. H. and Marks, W. E. The effects of changes of posture without active muscular exertion on the arterial and venous pressures. *Archiv. Internal Med.*, 1913, Vol. 11, pp. 485-494.
10. ——. The energy index, cardio-vascular energy as indicated by the arterial pressure per minute. *Jour. Amer. Med. Assn.*, 1914, Vol. 62, pp. 525-526.
11. Bardeen, C. R. Height-weight index of build in relation to linear and volumetric proportions and surface area of the body during post-natal development. Washington, Carnegie Institute, 1920, Pub. No. 272, pp. 485-554. (Contributions to Embryology, Nos. 27-45.)
12. Bean, R. B. Eruption of teeth as a physiological standard for testing development. *Ped. Sem.*, 1914, Vol. 21, pp. 596-614.
13. ——. Growth in stature. *Bur. Educ. Bul.*, 1915, No. 4, pp. 97-101.
14. Beik, A. K. Physiological age and school entrance. *Ped. Sem.*, 1913, Vol. 20, pp. 277-321.
15. Bernard, I. M. Vaso-motor efficiency, the Ward-Crampton index. *Sch. Hyg.*, 1916, Vol. 7, pp. 129-134.
16. Beyer, H. G. The relation between mental and physical work. *Amer. Phys. Ed. Rev.*, 1900, Vol. 5, pp. 149-160.
17. Boas, F. Growth. *Monroe's Cyclop. of Education.* N. Y., Macmillan, 1912, Vol. 2, pp. 187-190.
18. ——. Growth of children. *Science*, 1912, Vol. 36, pp. 815-818.
19. ——. Growth of Toronto children. *Rep. Com. of Educ.*, 1896-7, Vol. 2, pp. 1541-1599.
20. ——. Remarks on the anthropological study of children. Trans. 15th Intern'l Cong. Hyg. and Demog., 1912, Vol. 3, pp. 413-420.
21. —— and Wissler, C. Statistics of growth. *Rep. Comm. of Educ.*, 1904, Vol. 1, pp. 25-132.
22. Bowditch, H. P. Growth of children. Mass. State Board of Health Report, 1877, pp. 275-323.
23. ——. Growth of children (supplementary report). Mass. State Board of Health Report, 1879, pp. 33-62.
24. Brady, W. Personal health. Philadelphia, Saunders, 1916. 407 p.
25. Bryan, W. L. On the development of voluntary motor ability. *Am. Jour. Psychol.*, 1892, Vol. 5, pp. 125-204.
26. Bryant, J. Carnivorous and herbivorous types in man—the possibility and utility of their recognition. *Boston Med. and Surg. Jour.*, 1915, pp. 384-387.
27. ——. Poor health in the child—some developmental influences and their importance to the adult. *Boston Med. and Surg. Jour.*, 1914, Vol. 172, pp. 795-800.
28. ——. Physical types, dietary control, and preventive medicine. Conf. N. Eng. Pediatric Soc. Boston, Mass., 1916.
29. Burgerstein, L. Some remarks on the relation of body and mind. *Ped. Sem.*, 1910, Vol. 17, pp. 29-43.
30. Burk, F. From fundamental to accessory in the development of the nervous system and of movements. *Ped. Sem.*, 1898, Vol. 6, pp. 5-64.
31. ——. Growth of children in height and weight. *Am. Jour. Psychol.*, 1898, Vol. 9, pp. 253-326.
32. Burkhardt, C. H. Weight and height at various ages of life. *Mind and Body*, 1919, Vol. 25, pp. 428-430.
33. Burnham, W. H. Health examination at school entrance. *Ped. Sem.*, 1914, Vol. 21, pp. 219-241.

34. ——. Success and failure as conditions of mental health. *Mental Hygiene,* 1919, Vol. 3, pp. 387-397.
35. ——. The group as a stimulus to mental activity. *Science,* 1910, Vol. 31, pp. 761-767.
36. CANNON, W. B. Causes of rapid changes in body weight. *Jour. Amer. Med. Assoc.,* 1912, Vol. 59, pp. 725-771.
37. CHAPIN, H. D. Health first. New York, Century Co., 1917, 231 p.
38. CLERK, F. E. Study of the cardio-vascular index in elementary school children. *Ped. Sem.,* 1916, pp. 135-152.
39. CORNELL, W. S. Relation of physical to mental defects in school children. *Psychol. Clinic,* 1908, Vol. 1, pp. 231-234.
40. COURTIS, S. A. Measurement of the relation between physical and mental growth. *Am. Phys. Ed. Rev.,* 1917, Vol. 22, pp. 464-481.
41. CRAMPTON, C. W. Anatomical or physiological age vs. chronological age. *Ped. Sem.,* 1908, Vol. 15, pp. 230-237.
42. ——. Blood ptosis—a test of vaso-motor efficiency. Trans. 4th Intn'l Cong. Sch. Hyg., 1912, Vol. 5, pp. 555-560.
43. ——. Influence of physiological age on scholarship. *Psychol. Clinic,* 1907, Vol. 1, pp. 115-120.
44. ——. Physiological age—a fundamental principle. *Am. Phys. Ed. Rev.,* 1908, Vol. 13, pp. 141-154; 214-227; 268-283; 345-358.
45. ——. Significance of physiological age in education. Trans. Intn'l Cong. Hyg. and Demog., 1912, Vol. 3, pp. 224-236.
46. CRICHTON-BROWN, J. Growth, somatic and cerebral. *Child,* 1911, Vol. 2, pp. 1-16.
47. ——. Physical efficiency in children. Proc. 3d Intn'l Cong. for Welfare and Protection of Children, London, 1902, pp. 6-24.
48. DEBUSK, B. W. Height, weight, vital capacity and retardation. *Ped. Sem.,* 1913, Vol. 20, pp. 89-92.
49. ——. Vital index in development. *Ped. Sem.,* 1917, Vol. 24, pp. 1-18.
50. DEGIOVANNI, A. Lavori dell' Instituto di Clinica Medica di Padova. Milan, 1914, Hoepli.
51. ——. Clinical commentaries deduced from the morphology of the human body. New York, Putnam, n. d. 436 p.
52. DONALDSON, H. H. Growth of the brain. London, W. Scott, 1895. 374 p.
53 DOUGLAS, R. K. Society in China. London, Innes & Co., 1895. 434 p.
54. DUNHAM, F. L. Somatic development, a criterion of mental measurement. *Ped. Sem.,* 1915, Vol. 22, pp 305-325
54a. EMERSON, W. R. P. Is your child underweight? *Woman's Home Companion,* Aug., 1919.
55. FOSTER, W. L. Physiological age as a basis for the classification of pupils entering the high schools—relation of pubescence to height. *Psychol. Clinic,* 1910, Vol. 4, pp. 83-88.
56. FRANZ, S. I. Handbook of mental examination methods. New York, Macmillan, 1919. 193 p.
57. FREEMAN, K. J. Schools of Hellas. N. Y., Macmillan, 1907. 229 p.
58. GILBERT, J. A. Researches upon school children and college students. Univ. of Iowa Studies in Psychol., 1897, Vol. 1, pp. 1-39.
59. ——. Researches on mental and physical development of school children. Yale Psychol. Lab. Studies, 1894, Vol. 2, pp. 40-100.

60. Goldthwaite, J. E. Anatomic and mechanistic conception of disease. *Boston Med. and Surg. Jour.*, 1915, Vol. 172, pp. 881-898.
61. Greenwood, A. Health and physique of school children. London, King & Son, 1913. (Ratan Tata Foundation.) 96 p.
62. Hall, G. S. Adolescence. N. Y., Appleton, 1904, 2 Vols. 589 p. and 784 p.
63. Hallin, O. W. Schools and school children. *Am. Jour. Public Health*, 1919, Vol. 9, pp. 681-684.
64. Hancock, J. A. Preliminary study of motor ability. *Ped. Sem.*, 1894, Vol. 3, pp. 9-29.
65. Harding, H. W. Physique and mental ability of school children. *Child*, 1912, Vol. 2, pp. 766-768.
66. Harris, A. E. Growth and development of the modern secondary school boy. *Jour. of Sci. Phys. Trg.*, 1913, Vol. 5, pp. 65-69.
67. Hartwell, E. M. Bowditch's law of growth and what it teaches. Rep. A. A. A. P. E., 1896, pp. 23-30.
68. ——. Report, director of physical training. Boston, 1894, School Document No. 8. 151 p.
69. Hastings, W. W. Health and growth of school children. Proc. N. E. A., 1903, pp. 769-775.
70. ——. Manual for physical measurements, boys and girls Springfield, Mass., 1902. 112 p.
71. Hertz, P. Investigations on growth of children in Copenhagen elementary schools. *Sch. Hyg.*, 1912, Vol. 3, pp. 175-178.
72. Hogue, J. A. Report upon physical condition of children attending public schools of New South Wales. Sydney, Australia, 1908, pp. 56-57.
73. Holt, L. E. Standards for growth and nutrition. *Am. Jour. Dis. of Child*, 1918, Vol. 16, pp. 359ff.
74. Huntington, E. Civilization and climate. New Haven, Yale Univ. Press, 1915. 333 p.
75. Jackson, C. M. Changes in relative weights of the various parts, systems, and organs of young albino rats held at constant body weight by underfeeding for various periods. *Jour. Exper. Zool.*, 1915, Vol. 19, pp. 99-156.
76. James, W. W. and Pitts, A. T. Some notes on the dates of eruption in 4,850 children aged under 12. *Proc. Royal Soc. Med.*, 1912, Vol. 5, pp. 80-98. (Odontological Section.)
77. Judson, C. H. and Nicholson, M. D. Blood pressure in normal children. *Amer. Jour. Dis. of Child.*, 1914, Vol. 8, pp. 257-269.
78. Kelsey, H. E. Normal function of the child's denture in its relation to development of the jaws and other facial bones, and the preservation of teeth. *Bur. Educ. Bul.*, 1915, No. 50, pp. 68-72.
79. Kerr, James. Standard measurements for school children. *School Hygiene*, 1918, Vol. 9, pp. 4-15; *Mind and Body*, 1919, Vol. 26, pp. 193-207.
80. ——. Standard heights for school children. *School Hygiene*, 1917, Vol. 8, pp. 101-115.
81. King, I. Physiological age and school standing. *Psychol. Clinic*, 1914, Vol. 7, pp. 222-229.
82. Kirkpatrick, E. A. Studies in developing and learning. *Archiv. of Psychol.*, 1909, No. 12. 101 p.
83. Lay, W. A. Experimentelle Pädagogik. Leipzig, Teubner, 1908. 125 p.

84. Lehmann, A. and Pedersen, R. H. Das Wetter und unsere Arbeit. *Archiv f. d. ges. Psychol.*, 1907, Vol. 10, pp. 1-104.
85. Lewis, Charles B. Adolescent physical types; preliminary study. *Ped. Sem.*, 1916, Vol. 23, pp. 295-324.
86. Lowman, C. L. Applied anthropology. *Boston Med. and Surg. Jour.*, 1919, Vol. 180, pp. 693-695.
87. Luckey, G. W. A. Essentials of child study. Chicago, Univ. Pub. Col., 1917. 219 p.
88 McCurdy, J. H. Adolescent changes in heart rate and blood pressure. *Am. Phys. Educ. Rev.*, 1910, Vol. 15, pp. 421-432.
89. ——. Physical efficiency tests during adolescence. Trans. 15th Int'l. Cong. Hyg. and Demog., 1912, Vol. 3 (Part I), pp. 420-428.
90. MacDonald, A. Experimental study of children. Rep. Com. of Educ., 1897, Vol. 1, pp. 985-1204.
91. MacKenzie, W. L. Medical inspection of school children. Edinburgh and Glasgow, Wm. Hodge & Co., 1904. 455 p.
92. Manny, F. A. A scale for marking nutrition. *Sch. and Soc.*, 1916, Vol 3, pp. 123-124.
93. Marshall, J. S. Mouth hygiene and mouth sepsis. Phila., Lippincott, 1912. 262 p.
94. Mead, C. D. Height and weight of children in relation to general intelligence. *Ped. Sem.*, 1914, Vol. 21, pp. 394-405.
94a. ——. Relations of general intelligence to certain mental and physical traits. New York, Columbia Contributions to Educ., 1917, No. 76. 117 p.
95. Minot, C. J. The problem of age, growth and death. *Pop. Sci. Mo.*, 1907, Vol. 71, pp. 97-120; 193-216; 359-377; 455-473; 509-523.
96. Monroe, Paul. Textbook in the history of education. New York, Macmillan, 1906. 772 p.
97. Montessori, M. Pedagogical anthropology. N. Y., Stokes, 1913. 508 p.
98. Myers, G. C. Grasping, reaching and holding. *Amer. Jr. of Psychol.*, 1915, Vol. 26, pp. 525-539.
99. Newmayer, S. W. Medical and sanitary inspection of schools. Boston, Lea, 1913, pp. 207-229.
100. Osborne, T. B. and Mendel, L. B. The suppression of growth, and the capacity to grow. *Jour. Biol. Chem.*, 1914, Vol. 18, pp. 95-106.
101. ——. The resumption of growth after long continued failure to grow. *Jour. Biol. Chem.*, 1915, Vol. 23, pp. 439-454.
102. ——. Acceleration of growth after retardation. *Amer. Jour. Physiology*, 1916, Vol. 40, pp. 16-20.
103. Paton, S. Psychiatry. Phila., Lippincott, 1905. 617 p.
104. Pearson, Karl. On the relationship of intelligence to size and shape of head, and to other mental and physical character. *Biometrika*, 1906, Vol. 5, pp. 105-146.
105. Peckham, G. W. Growth of children. Sixth Ann. Rept. State Board of Health, Wisconsin, Public Doc. No. 14. 46 p.
106. Penn, B. A schoolmaster's notes on growth of scholars. *Sch. Hyg.*, 1917, Vol. 8, pp. 116-122.
107. Porter, W. T. Anthropometric measurements in schools. *Educ. Rev.*, 1896, Vol. 11, pp. 126-133.
108. ——. Growth of St. Louis children. Trans. St. Louis Acad. of Science, 1894, Vol. 6, pp. 263-380.

109. ——. Physical basis of precocity and dullness. Trans. St. Louis Acad. of Sci., 1893, Vol. 6, pp. 162-181.
109a. The seasonal variation in growth of Boston school children, *Am. Jour. Physiol.,* 52: 121-131, May 1 ,1920.
110. Pryor, J. W. Chronology and ossification of human carpus. Bul. State Univ of Ky, 1905, 1906, 1908.
111. ——. Some observations on the ossification of the bones of the hand. Bul. State Univ. of Ky., 1916. 67 p.
112. Pyle, W. H. The examination of school children. New York, Macmillan, 1912. 70 p.
113. ——. Manual for mental and physical examination of school children. Univ. of Missouri Bul., 1916, **Vol. 17,** 32 p.
114. Retan, G. M. The measure and development of nutrition in childhood. *N. Y. State Jour. Med.,* 1919, Vol. 19, pp. 397-400.
115. Ripley, W. Z. The racial geography of Europe. *Pop. Sci. Mo.,* 1897, Vol. 51, pp. 17-34.
116. Roberts, C. Memorandum on medical inspection of and physical education in secondary schools. Rept. Royal Com. on Secondary Educ., London, 1895, Vol. 5, pp. 352-374.
117. Robertson, T. B. Variability of weights and stature of school children and its relationship to their physical welfare. *Am. Jour. Physiology,* 1916, Vol. 37, pp. 547-554.
118. Rotch, T. M. Development of bones in early life studied by Roentgen methods for the determination of anatomic index. Trans. Assn. of Am. Physicians, 1909.
119. ——. Labor and work of children should be adapted to the individual child. Trans. Intnl. Cong. Hyg. and Demog., 1912, Vol. 3, pp. 975-984.
120. ——. Roentgen ray methods applied to grading of early life. *Am. Phys. Ed. Rev.,* 1910, Vol. 15, pp. 396-420.
121. Rowe, S. H. Physical nature of the child, and how to study it. New York, Macmillan, 1899. 207 p.
122. ——. School and child's physical development. Proc. N. E. A., 1905, pp. 742-749.
123. Rusk, R. R. Experimental education. N. Y., Longmans, 1919. 346 p.
124. Sandiford, P. Mental and physical life of school children. N. Y., Longmans, 1913. 346 p.
125. Schuyten, M. C. Nutrition coefficients of Antwerp school children. *Sch. Hyg.,* 1913, Vol. 4, pp. 51-53.
126. Shrubsall, F. C. Some notes on anthropometric measurements and their interpretation *Sch. Hyg.,* 1910, Vol. 1, pp. 380-387.
127. Smedley, F. W. Department of child study. Chicago, 1900, Report No. 2, 72 p.; 1902, Report No. 3, 63 p.
128. Stephenson, W. On the rate of growth in children. Trans. 9th Intnl. Med. Cong., 1887, Vol. 3, pp. 447-452.
129. ——. The relation of weight to height and the rate of growth in men. *Lancet,* 1888, Vol. 2, pp. 560-564.
130. Stiles, C. W. Lung capacity of children. Pub. Health Reports, 1915, Vol. 30, pp. 3067-3072.
131. Taylor, C. K. Better boys, new standard for judging your boy's physical development. *Amer. Mag.,* 1914, Vol. 77, pp. 17-22.
132. ——. Physical examination and training of children. Phila., Winston, 1914. 93 p.
133. Thompson, D'A. W. On growth and form. N. Y., Putnam, 1917. 793 p.

134. Triplett, N. The dynamogenic factors in pace-making and competition. *Amer. Jour. Psychology,* 1898, Vol. 9, pp. 507-533.
135. Tuxford, A. W. The measure of physical development in school children. *Sch. Hyg.,* 1917, Vol. 8, pp. 65-69.
136. Tyler, J. M. Growth and education. Boston, Houghton, 1907. 294 p.
137. ——. Study of growth in children. Proc. N. E. A., 1908, pp. 913-916.
138. Waller, J. O. Mental and physical training of children. *Pop. Sci. Mo.,* 1889, Vol. 36, pp. 213-222.
139. Wallin, J. E. W. Psycho-motor norms for practical diagnosis. *Psychological Monographs,* 1916, Vol. 22, No. 3, pp. 1-102.
140. West, G. M. Growth of the human body. *Educ. Rev.,* 1896, Vol. 12, pp. 284-289.
141. ——. Observation on relation of physical development to intellectual ability. *Science,* 1896, Vol. 4, pp. 156-159.
142. Whipple, G. M. Manual of mental and physical tests. Baltimore, Warwick and York, 1915, 2 Vols. 352 p. and 336 p.
143. Winch, W. H. When should a child begin school? *Educ. Psych. Monographs,* 1911. 98 p.
144. Wood, T. W. Health and education. Year book, National Soc. for Study of Educ., 1910, part I. 113 p.
145. Woodrow, H. Brightness and dullness in children Phila., Lippincott, 1919. 322 p.
146. Woolley, H. T. New scale of mental and physical measurements for adults. *Jour. Educ. Psych.,* 1915, Vol. 6, pp. 521-550.
147. Wright, G. H. Functional relation of the tonsils to the teeth. *Boston Med. and Surg. Jour.,* 1909, Vol. 160, pp. 634-641.
148. Zigler, M. J. Developmental changes at the six year period. M. A. Thesis, Clark University, 1917. 87 p.
149. Zirkle, N. W. Medical inspection of schools. Univ. of Col. Bul., 1902, Vol. 1. 66 p.

A MENTAL SURVEY OF FIRST GRADE SCHOOL PUPILS

By Margaret B. Edmondson

Introduction

That individuals differ in mental endowment throughout life has long been recognized. That this difference is shown in their ability or inability to profit from school instruction in the earliest years of school life is also commonly admitted among educators. However, it is only with the perfecting of "mental measuring rods" in the form of "Intelligence Scales" that the exact degrees of these differences or their distribution and relationship to school success or failure, can be even approximated.

We have been seeking to measure the efficiency of school systems, courses and teachers in terms of the response secured from pupils to standard questions. Students of the subject are coming more and more to realize that in order to make this a really just and accurate test, the intelligence level of the pupils should be rated first. Are the pupils of school A and school B really comparable?

Account must be taken of the work a pupil should be doing at his given mental age in measuring his retardation or acceleration, or the efficiency of the instruction he is receiving.

A mental test has been found to be the best means of segregating those for whom the regular work is unsuitable because of difference in endowment. The test picks out those for whom special instruction should be provided, in justice to themselves as well as the normal children of the grade and the teacher.

Progressive school supervisors are beginning to realize the advantage to be gained through a knowledge of the facts revealed in regard to their pupils by the intelligence tests. With the hope of demonstrating the advantage of gaining this knowledge at the outset of the school career of the pupils and of basing their classification and instruction on this knowledge, this study was made.

A careful survey of the literature revealed no such general and complete survey of beginning school pupils as is here

attempted.[1] Studies bearing relationship to particular phases of the problem are noted in their proper places.

The data serving as a basis for this report consist of individual tests of the 183 first grade pupils of the public schools of Eugene, Oregon. The Stanford[2] Revision of the Binet-Simon Scale was used. The tests were all given by the writer during the period between the middle of December, 1918, and the middle of April, 1919.

All tests were given in small private rooms of the school buildings during school hours. Surroundings were made as nearly uniform in all buildings as possible. Distractions were minimized to the lowest possible limit. Thus those unavoidable differences which tend to vitiate the results from the use of this scale, through the personal equation of the examiner and different conditions at the time of giving the tests, were reduced to a minimum.

In a few cases the teacher was present because of desire to see the scale used. She, however, remained as unobtrusive as possible. Her presence did not seem to affect the result in any way.

In only one case was great reluctance displayed on the part of the subject. This was found to be due to the idea that it was to be a throat examination. As soon as the work was begun his reluctance vanished. He then admitted that he liked it. Most of the children considered it merely a novel and interesting experience and eagerly awaited their turns.

The population of Eugene is almost entirely native American middle class. There is no great wealth and little extreme poverty. All children attend the public schools. The school districts are so arranged that each draws about the same proportion of children from cultured and uncultured homes.

The group is a fair sample of the native American-born children of the north-west. There were no Oriental or colored children in the rooms studied. As is true throughout the west, a very large proportion were born outside the state, probably more than two-thirds. Every section of the United States is represented and a number are of Canadian birth. Only one foreign-born child of foreign parentage is included. She was born in Edinburgh, Scotland. In only one case is the family known to use a language other than English in the home. This is a Swedish boy. Language difficulty may have

[1] Written prior to publication of The Intelligence of School Children, by Terman: Chapter 4, Individual Differences in the First Grade.

[2] Terman, Stanford Revision Binet-Simon Scale, Warwick & York, 1917; The Measurement of Intelligence, Houghton, Mifflin Co., 1916.

vitiated the test somewhat in this case. Noticeable differences due to language or race therefore were not encountered.

The time required for giving the tests ranged from one-half hour to more than an hour, averaging about forty-five minutes. Effort was made to keep the children's attention strictly on the tasks before them, but none was hurried.

On the assumption that 6 year old children might fail on some 5 year tests, all pupils were started with the four year series. This gave a fair sample of all kinds of tests with response simple enough to gain confidence and awaken interest.

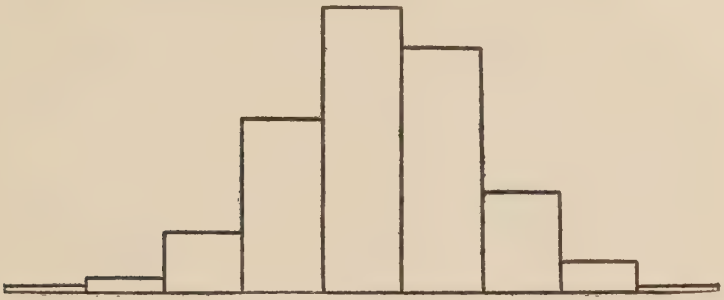
In all cases the tests were given practically in the order printed in the record sheet. The instructions were strictly followed. The full regular series of six tests for each year was used with the exception of year 10. As the vocabulary score was used for year 8 this was omitted in year 10. Also the reading test (10-4) was found unsuitable for first year pupils as it implied more formal education than they had had in order to read the passage. Consequently alternatives 1 and 2 were substituted. No tests were passed above year 10. Most normal cases failed in the 9 year group.

Data and Discussion

The distribution of the intelligence quotients of the whole 183 cases is represented in Graph 1. This surface does not present an ideal distribution. There are 107 pupils 100 I. Q. and below or 58.2%, and 76 above 100 or 41.4%. This is readily explained by reference to Graphs 2 and 3 where the beginners and repeaters are represented separately. Here the beginners present a normal distribution, there being 67 above 100 I. Q. and 66 just 100 or below that point. The repeaters group themselves about 90 I. Q. as a median, since 56% is above and 44% is below this point. This is in agreement with the findings of Terman[3] for older retarded children in the grades and shows roughly the relationship between intelligence as measured by this scale and grade progress.

Three pupils tested below 70 (50.5, 60.5, and 68), while only one tested above 130 (136). Eliminating the repeaters, however, gives again a symmetrical distribution of 7 each above 120 and below 80. So the assumption that more extreme cases of deficiency than of superiority are found is apparently without foundation, so far as the school population of Eugene is concerned. The most defective children

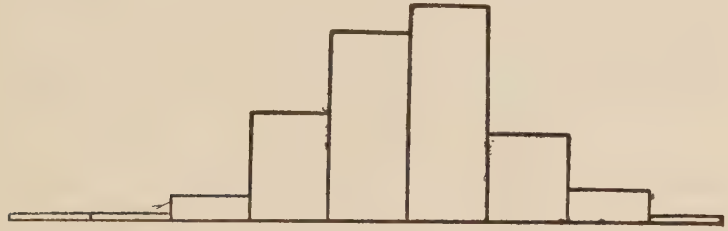
[3] Terman, Stanford Revision, p. 32.



50.5–60	60.5–70	70.5–80	80.5–90	90.5–100	100.5–110	110.5–120	120.5–130	130.5–140
0.54%	1.09%	6.5%	19.1%	31.1%	26.7%	10.9%	3.27%	0.54%

GRAPH 1. DISTRIBUTION OF I. Q.S OF 183 FIRST GRADE CHILDREN

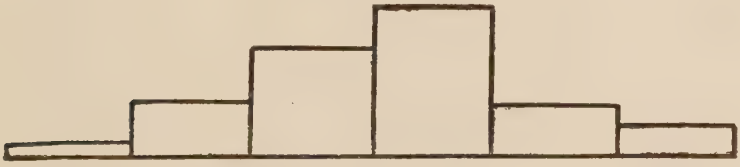
Above 100 I. Q. 76. Below 100 I. Q. 107.



50.5–60	60.5–70	70.5–80	80.5–90	90.5–100	100.5–110	110.5–120	120.5–130	130.5–140
0.75%	0.75%	3.7%	15.7%	28.5%	32.3%	12.8%	4.5%	0.75%

GRAPH 2. DISTRIBUTION OF I. Q.S OF 133 BEGINNING FIRST GRADE CHILDREN.

Above 100 I. Q. 67. Below 100 I. Q. 66.



60.5–70	70.5–80	80.5–90	90.5–100	100.5–110	110.5–120
2%	14%	28%	38%	12%	6%

GRAPH 3. DISTRIBUTION OF I. Q.S OF 50 REPEATING FIRST GRADE CHILDREN

Above 100 I. Q. 9. Below 100 I. Q. 41.

are of course not in the public schools. This again agrees with Terman's findings.[4]

Some studies of retardation begin with the third grade and state that it is a negligible factor below that grade. This study reveals the fact that 50 out of 183 pupils are repeaters in the first grade. Only 9 of this number have an I. Q. above 100. This places the beginning of the problem of the repeater with the first year of school life and shows the very great need of mental tests for school entrance that all may at least start the educational lock-step with an even chance.

The distribution of the chronological and mental ages of the 183 first grade pupils studied is shown in Table 1.

In both chronological and mental ages the groups are divided as follows: three years and one month to four years, four years and one month to five years, etc.

The chronological age is stated at the top of the table reading across the page. The mental age appears at the left reading down. The total distribution of chronological ages is given at the bottom reading horizontally and that of the mental ages at the right reading vertically.

The extremes represented by these beginning school pupils are probably as great as will be found at any age of school

TABLE 1

DISTRIBUTION OF CHRONOLOGICAL AND MENTAL AGES

Chron. Age / Mental Age	5 yr. 1 mo. to 6 yr.	6 yr 1 mo. to 7 yr.	7 yr. 1 mo. to 8 yr.	8 yr. 1 mo. to 9 yr.	9 yr. 1 mo. to 10 yr.	Total	Per Cent.
3 yr. 1 mo. to 4 yr.	..	1	..	..	..	1	0.5%
4 yr. 1 mo. to 5 yr.	..	3	..	1	..	4	2.0%
5 yr. 1 mo. to 6 yr.	1	16	3	..	..	20	10.9%
6 yr. 1 mo. to 7 yr.	3	38	23	9	..	73	39.8%
7 yr. 1 mo. to 8 yr.	1	25	30	7	1	64	35.1%
8 yr. 1 mo. to 9 yr.	..	6	11	3	..	20	10.9%
9 yr. 1 mo. to 10 yr.	..	..	..	..	1	1	0.5%
Total.....	5	89	67	20	2	183	100. %
Percent.....	2.7%	48.6%	36.6%	10.9%	1.0%	100.%	..

Average Chron. Age 7 yr. 2.1 mo. A. D. 7.27 mo.
Average Mental Age 6 yr. 11.4 mo. A. D. 7.7 mo.

[4] Idem, p. 44.

life. This agrees with Terman's conclusion[5] that the popular belief that the range increases with age is not founded.

The range of chronological ages covers 5 years with 85.2% falling between 6 years 1 month and 8 years.

51.3% of these pupils is 7 years old or less.

11.9% is retarded already on the age basis.

In mental age the range of these pupils covers 7 years with 50.7% falling in the 6 year 1 month to 8 year groups.

11.4% is retarded according to this classification. These pupils are mentally too old for the first grade even when allowance is made for entrance at 7 years of age.

13.4% of all is mentally under the age of school entrance in the spring after an average attendance of more than six months.

This range is somewhat greater than that found by Kuhlmann[6] in Faribault, Minnesota. Here his first grade pupils covered a range of 5 years, by far the largest number falling in the 7 year group. His were also examined in the spring. As he fails to state his group limits definitely exact comparison is impossible. Kuhlmann says,

"These conditions are surely far from ideal. Imagine what changes might result to the benefit of both the teachers and the children if all the children of any school grade were of one and the same mental age. The reasons for this lack of adaptation of teaching to the grade of intelligence of the individual children are undoubtedly many. I shall attempt to show, however, that it is largely due to the fact that the schools do not know the grade of intelligence of the individual child, nor the training capacity of each grade of intelligence as well as they might."

It is evident that a large number of the children should be more advanced in school than they are. The exact number depends upon the old question whether a child should begin school life at six years of age or not until he is seven.

Belief of parents that their children should not start to school until they are 7 years old, or nearly so, accounts in part for this situation and complicates the grading problem. Pedagogical retardation due to frequent changes of schools accounts for another part. These children are repeaters while being mentally accelerated. Illness and consequent absence from school is a third factor. The rest are the unusually bright who so far have not profited by their unusual endowment but are marking time in a grade too easy for them and learning, at the beginning of their school career, habits of laziness and less than normal effort.

---

[5] Terman, Stanford Revision, p. 39.

[6] Kuhlmann, The Importance and Methods of Detemining the Mental Age of Sub-Normal Children, *Proceedings* of 62d Annual Session, Wis. Teachers' Ass'n., pp. 291 ff.

The child only 3 years old mentally is obviously feeble-minded.

The 4 year old group and most of the 5 year are borderline or doubtful cases, at best, according to Terman's[7] standards. They are all doing very poor school work. They are retarding the classes wherever they are found and are a constant strain on the vitality of the teachers. The teachers all make the same reply when asked about these pupils. "If we were not compelled to devote so much time to these few we could do so much more with the others and go so much faster and farther in our work."

Terman[8] raises the question whether school groups are more homogeneous mentally than chronologically and answers it in the negative. His conclusion seems to be entirely borne out by our data.

TABLE 2

DISTRIBUTION OF CHRONOLOGICAL AGES AND INTELLIGENCE QUOTIENTS

Chron. Age I Q.	5 yr. 1 mo. to 6 yr.	6 yr. 1 mo. to 7 yr.	7 yr. 1 mo. to 8 yr.	8 yr. 1 mo. to 9 yr.	9 yr. 1 mo. to 10 yr.	Total	Per Cent.
50.5–60	..	1	..	..	..	1	0.5%
60.5–70	..	..	1	1	..	2	1.09%
70.5–80	..	4	1	6	1	12	6.5 %
80.5–90	..	11	15	9	..	35	19.1 %
90.5–100	1	24	28	3	1	57	31.1 %
100.5–110	2	34	12	1	..	49	26.7 %
110.5–120	1	10	9	..	..	20	10.9 %
120.5–130	1	4	1	..	..	6	3.27%
130.5–140	..	1	..	..	..	1	0.5 %
Total.....	5	89	67	20	2	183	100%
Percent.....	2.7%	48.6%	36.6%	10.9%	1.0%	100%	

Average Chron. Age 7 yr. 2.1 mo. A. D. 7.27 mo.
Average I. Q. 97.4 A. D. 10.23

Table 2 shows the distribution of the chronological ages and intelligence quotients of the 183 pupils. As in Table 1, the chronological ages are indicated at the top reading across the page. The intelligence quotients are grouped by tens at the left, 50.5 to 60, 60.5 to 70, etc., reading down the page. The total for each chronological year appears again at the bottom of the table reading horizontally and the total for each intelligence quotient group is at the right reading vertically.

[7] Measurement of Intelligence, p .79.
[8] Stanford Revision, p. 113.

The scattering here shows again conclusively the heterogeneity of these pupils who are supposed to do the same school work.

57.8% falls in the so-called "normal" group, namely, from 90 to 110 I. Q. But these pupils are not, as might appear at first thought from the graphs, a homogeneous group. They are scattered over five years chronological age. The mere fact that the pupils of a group show normal intelligence through their I. Q.'s and that a large number of them are chronologically at the age supposed to fit their school grade does not necessarily give a homogeneous group from the pedagogical standpoint. They are not necessarily well graded. The I. Q. alone is not a reliable means of classification. It is a means of designating individual rating only. Mental age is a far more reliable basis for classification of school pupils.

Each teacher was asked to grade her class according to the system in use in the city, namely, A, B, C, D, and E, D representing condition and E failure. Instead of grading each subject, however, she was asked to assign one letter to each pupil which would represent an average of the pupil's work and to take into consideration only the work actually accomplished by the pupils. Illness, change of schools, etc., which tend to place a pupil lower in the grade than he would be had he an even chance with the others, were not allowed to influence the teacher's markings.

The writer is fully aware of the fallacies involved in this system due to individual differences of the teachers, differences in their standards or their emphasis on different parts of the work in assigning one grade to represent all. However, this may be accepted as at least approximating the achievement of each pupil.

On this basis the pupils were divided into five groups according to the quality of work done. Each was then divided into two, one consisting of those whose intelligence quotients were 100 or below and one containing those 100.5 and above. The chronological age for each group was then averaged. These results are tabulated in Table 3.

The average chronological age of pupils above 100 I. Q. is 6 years 9.9 months with an average deviation of 4.4 months. The average of those 100 I. Q. and below is 7 years 5.2 months with an average deviation of 8 months. The average chronological age of all pupils studied (183) is 7 years 2.1 months with an average deviation of 7.27 months.

Several significant facts are shown in this table.

TABLE 3

AVERAGE CHRONOLOGICAL AGE

Pupils Grade	No.	Above 100 I. Q.	No.	Below 100. I. Q.	No. Total	All I. Q.s.
A.	29	6 yr. 11.1 mo.	20	7 yr. 10.3 mo.	49	7 yr. 3.6 mo.
B.	24	6 yr. 10.9 mo.	24	7 yr. 8.4 mo.	48	7 yr. 3.7 mo.
C.	15	6 yr. 8.5 mo.	25	7 yr. 4.6 mo.	40	7 yr. 1.5 mo.
D.	6	6 yr. 6.3 mo.	8	7 yr. 1.4 mo.	14	6 yr. 10.3 mo.
E.	2	6 yr. 3.0 mo.	30	7 yr. 0.7 mo.	32	7 yr.
Total	76	6 yr. 9.9 mo.	107	7 yr. 5.2 mo.	183	7 yr. 2.1 mo.

A.D. Above 100 I.Q. 4.4 mo.
A.D. Below 100 I.Q. 8. mo.
A.D. All I.Q.s 7.27 mo.

In the first place, the average chronological age of those pupils having an I. Q. 100 and below is 7 months greater than that of those above 100 I. Q. doing the same quality of school work. In the A and B groups, or those doing satisfactory work, the difference averages almost a year. The difference is less noticeable in those groups doing a poorer quality of school work.

The group above 100 I. Q. is more homogeneous chronologically than that below 100. This is shown by the fact that the average deviation of the former is only 4.4 months, while that of the latter is 8. months. This latter group is one which requires individual attention. The pupils are not alike and cannot be well handled in large classes. They are the repeaters, the failures, and the general misfits. Only two pupils with an I. Q. above 100 are in the E class and they are shown by their average age to be very young. It is not lack of endowment but inability to adjust themselves to school work as yet. According to their teacher, "They are just babies."

This table also shows that on the average the older pupils do better work. The chronological age decreases with the quality of work for all groups. The difference in chronological age between the A and E groups averages 8. months for those above 100 I. Q. and 9.6 months for those 100 and below. This is logically to be expected from minds in the years of growth.

A difference of 6 months in the average chronological age was noted between schools for the groups above 100 I. Q. The difference was a year and 5 months for those 100 I. Q. and below. The rooms with a high percentage of repeaters were oldest. Thus it is readily seen that comparisons of the work accomplished in these different rooms in the same school

system are unjust unless consideration is given to the difference in age of the pupils and the number of them who have been in school before.

Using the teachers' estimates of the quality of the pupils' work again as a basis, they were divided into the 5 groups A, B, C, D, and E. The average mental age was then computed for each group.

49	A pupils have an average mental age of	7 yr. 5.3 mo.
48	B " " " " "	" 7 yr. 3.6 mo.
40	C " " " " "	" 6 yr. 10.8 mo.
14	D " " " " "	" 6 yr. 7.4 mo.
32	E " " " " "	" 6 yr. 0.6 mo.
183	First grade pupils	6 yr. 11.4 mo.
	A.D. 7.7 mo.	

A difference in mental age of a year and 5 months is shown here between the averages for the A and E groups. The difference becomes greater with descent in the quality of work done. It is 1.7 months between A and B groups, 4.8 months between B and C, 3.4 months between C and D, and 6.8 months between D and E. This suggests again the advisability and usefulness of mental tests for classification of pupils.

In only two of the rooms studied, or less than one-fourth of the failures, is the average mental age of the failing pupils more than 6 years. They are all chronologically much older except the two pupils referred to above who have intelligence quotients above 100 and are 6 years 2 months and 6 years 4 months old respectively. This is significant in the light of the recent suggestion that a mental test be made the basis of entrance into the first grade.

As only 3 of the 32 failing pupils are repeaters and only 12 are mentally 6 years old in the spring after having been in school an average of more than 6 months, it seems a justifiable conclusion that a mental test for entrance is one way of at least partly solving the problem of the pupil who cannot do the work, retards the class, and uses up the energy of the teacher. Since 25 have been shown by Table 1 to be mentally 6 or below and only 5 of these are classed by their teachers as doing work good enough to merit a condition in the second grade next year, the requirement that a child shall be mentally 6 years old to enter school appears just and reasonable.

This table also shows the need of segregation of the inferior pupils. Even at the beginning of school life, a standard set for the so-called "average" child, while proving ex-

ceedingly easy for some, is too difficult for the less well endowed. Habits of failure and of expecting to fail are allowed to develop from the earliest school life. This is most detrimental from the psychological standpoint. It is bad alike for the poor pupils, the brighter ones who are not required to work to maintain their standing, and the teachers who are compelled to put a certain proportion of this heterogeneous group through a certain portion of the curriculum in a certain time regardless of the pupils' ability to grasp it. The teacher with a large number of pupils of poorer mentality worries because her proportion of failures for the year will be too great. The bright pupil informs the examiner that the test will be very easy for her " because everything is easy."

A comparison of these last figures with Table 3 shows that the average mental age of A pupils is higher than their chronological age. This becomes approximately equal for B pupils. The mental drops below the chronological for C pupils, the difference becoming increasingly great in the D and E groups.

A comparison was made of the average mental age of the beginners and repeaters. For the whole number (133) beginners the average mental age is 6 years 10.5 months with an average deviation of 8.06 months. For the 50 repeaters the average mental age is 7 years 2.9 months with an average deviation of 7.38 months. The difference is 4.5 months. This again indicates pedagogical retardation.

A number of pupils were found to be repeating, some even for the second time, who were not mentally retarded. The apparent reason was frequent change of schools. They are losing valuable time for want of a little special coaching to bring up special deficiencies due to difference in course of study. The system of yearly promotions is a hardship to some of these pupils also. A mental test would have shown the ultimate economy of the special teacher for a short time. They should not be forced to lose so much time as they are losing.

A study of the intelligence quotients of the pupils of different chronological ages was made. They were divided into year groups on the basis of chronological age. Those from 6 to 7 years old (including 2 not yet quite 6 and 3 just 6 years old) were placed in one group. Those from 7 years 1 month to 8 years were placed in the second group. Those from 8 years 1 month to 9 years (including 2 over 9 years old) composed the third group. The intelligence quotients were then averaged for each group.

93 pupils 6–7 yrs. old average I.Q. 101.4 A.D. 8.6
68 pupils 7 yr. 1 mo.–8 yr. old average I.Q. 96.2 A.D. 8.57
22 pupils 8 yr. 1 mo.–9 yr. old average I.Q. 84.3 A.D. 7.54

The average I. Q. for the 183 cases is 97.4 with an average deviation of 10.23.

This indicates the result of selection. The pupils mentally normal or accelerated outstrip their less well endowed fellows very early in their educational career. The laggards are apparent here in the first grade. They can be as easily segregated here for special attention and individual study as later when habits of failure and dislike of school are fixed and much valuable time has been lost. Were it not for the cases of pedagogical retardation mentioned above, the difference in these averages would be greater than it here appears. These few cases raise the average I. Q. of the older pupils so that the two kinds of retardation tend to offset each other in the averages but are easily distinguishable by the tests.

TABLE 4

AVERAGE INTELLIGENCE QUOTIENT

	No.	A.	No.	B.	No.	C.	No.	D.	No.	E.	No.	Total
Beginners	32	108.	28	104.3	30	100.2	14	96.5	29	87.6	133	99.8
Repeaters	17	91.3	20	94.5	10	88.1	..	....	3	74.8	50	90.9
Total	49	102.3	48	100.2	40	97.2	14	96.5	32	86.4	183	97.4

A. D. 10.23

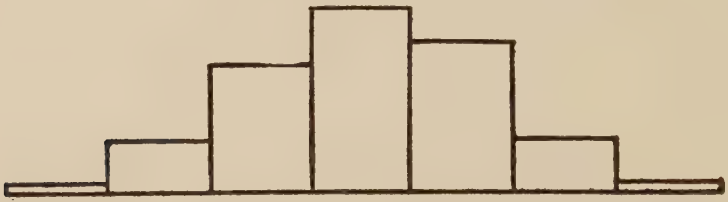
For Table 4 the pupils were divided into the same 5 groups, A, B, C, D, and E, as above, according to the teachers' estimates. The intelligence quotients were then averaged for these groups as a whole and also for the beginners and repeaters separately.

A difference of 16.7 points is shown between the average I. Q.'s of beginners and repeaters doing A work. The difference is 9.8 points for the B grade, 12.1 for the C grade, and 13.8 for the E grade. There are no repeaters doing D work. The difference averages 8.9 points for all grades.

For the beginners the average I. Q. for both A and B grades is above 100 and for C grade it is 100. For all pupils the average for A work is above 100. It falls to approximately 100 for the B grade and below 100 for C, D, and E groups, growing progressively lower. The difference in I. Q. between A and B grades is 2.1 points. Between B and C grades it is 3. points. Between C and D it is .7 point, while between D and E it is 10.4 points. The very low I. Q.'s of some of the failures (borderline cases at best) are no doubt responsible for this last very great discrepancy.

The progressive decrease in the I. Q. of the beginners from A to E groups shows that, age being approximately constant, the quality of work varies directly as the I. Q.

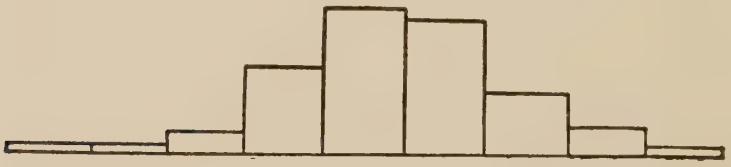
An attempt was made to find the sex differences among these pupils, if any exist. The results of these studies appear in graphs 4 and 5 and Table 5.



60.5–70	70.5–80	80.5–90	90.5–100	100.5–110	110.5–120	120.5–130
1.1%	8.8%	22.2%	32.2%	25.5%	8.8%	1.1%

GRAPH 4. DISTRIBUTION OF I. Q.S OF 89 FIRST GRADE BOYS.

Above 100 I. Q. 32. Below 100 I. Q. 57.



50.5–60	60.5–70	70.5–80	80.5–90	90.5–100	100.5–110	110.5–120	120.5–130	130.5–140
1%	1%	4.3%	16.1%	30.1%	27.9%	12.9%	5.3%	1%

GRAPH 5. DISTRIBUTION OF I. Q.S OF 93 FIRST GRADE GIRLS

Above 100 I. Q. 44. Below 100 I. Q. 49.

The extremes of distribution of the boys are 68 and 121.5 I. Q. Those of the girls are 51.5 and 136.

57.7% of the boys falls in the "normal" groups (90-110 I. Q.). 57% of the girls are so classed.

9.9% of boys is "superior." 19.2% of girls has this classification.

32.1% of boys is "inferior" as against 22.4% of girls.

Of the boys 35.4% is above 100 I. Q. and 64.3% is below.

Of the girls 47.1% is above 100 I. Q. and 52.5% is below.

These percentages are somewhat lower than Cuneo and Terman[9] found for 112 kindergarten children in California. They are in agreement, however, in the fact that the median for girls is somewhat higher than that for boys. There is disagreement in that for the kindergarten children the range of distribution of the boys exceeded that of the girls while this study shows the range for the girls to be somewhat greater. The range of kindergarten boys is 61-152 while this study shows 68-121.5. That of kindergarten girls is 75-146 while this study shows 50.5-136.1 I. Q. Exact comparisons of the percents in each intelligence quotient group or even above and below 100 I. Q. are impossible because the group limits are different in the two studies.

In Table 5 the groups of pupils doing the different grades of school work were divided according to sex. Here of all pupils there is a slight superiority of average I. Q.'s for the

TABLE 5

AVERAGE INTELLIGENCE QUOTIENT OF THE SEXES

		No.	A.	No.	B.	No.	C.	No.	D.	No.	E.	No.	Total
Total.....	Boys	20	101.3	19	98.3	24	96.4	4	93.3	22	87.9	89	95.6
	Girls	29	102.9	29	101.1	16	98.3	10	97.7	10	83.1	94	99.
Beginners....	Boys	12	109.3	10	104.5	18	99.9	4	93.3	20	88.5	64	98.4
	Girls	20	107.3	18	104.3	12	100.8	10	97.7	9	85.6	69	101.1
Repeaters....	Boys	8	89.2	9	91.5	6	86.	..	....	2	82.	25	88.7
	Girls	9	93.3	11	96.9	4	91.1	..	....	1	60.5	25	90.8

A. D. Boys 9.38 Girls 10.66

girls in all classes except the failures. This difference is 1.6 points for A pupils, 2.8 points for B pupils, 1.9 points for C pupils and 4.4 points for D pupils. The results are reversed in the E groups because two feeble-minded girls (sisters) having I. Q.'s of 51.5 and 60.5 respectively, are included in the averages while the lowest boy reaches 68.

A difference of 3.4 points in the averages for all pupils of each sex is noted, the boys having an average of 95.6 and the girls 99 I. Q. The average deviation for the boys is 9.38 while for the girls it is 10.66.

The attempt to find sex differences was carried farther by segregating the beginners and repeaters. Here the beginners among the boys are slightly superior in A and B groups, but the average again shows girls to be 2.7 points better. Among the repeaters the girls are uniformly superior to the boys except in the E group. Only one girl is repeating and failing

[9] Cuneo & Terman, Stanford-Binet Tests of 112 Kindergarten Children & 77 Repeated Tests, *Ped. Sem.*, 1918, 25: 414-428.

the second time. She is one of the feeble-minded mentioned above. The difference between the sexes here is only 2.1 points. however. The same fact that was shown to be true of the sexes together appears here also when averaged separately, namely, that there is 10 points difference in the average I. Q.'s of the beginners and the repeaters doing the same quality of school work. The median for repeaters is 90 I. Q. The girls repeating average 90.8 and the boys 88.7 I. Q.

The distribution of the intelligence quotients and the teachers' estimates of the quality of school work accomplished for all pupils studied is given in Table 6.

TABLE 6

DISTRIBUTION OF INTELLIGENCE QUOTIENTS AND SCHOOL GRADES

I. Q. / Grade	50.5–60	60.5–70	70.5–80	80.5–90	90.5–100	100.5–110	110.5–120	120.5–130	130.5–140	Total
E—	1	..	5	5	3	1	..	..	..	15
E+	..	2	..	4	10	1	..	..	..	17
D—	..	..	..	3	2	2	1	..	..	8
D+	..	..	..	1	2	3	..	..	..	6
C—	..	..	3	4	6	5	1	..	..	19
C+	..	..	1	1	10	5	3	1	..	21
B—	..	..	1	4	6	9	1	..	..	21
B+	..	..	..	7	6	7	5	1	1	27
A—	..	..	1	2	5	7	6	2	..	23
A+	..	..	1	4	7	9	3	2	..	26
Total	1	2	12	35	57	49	20	6	1	183
								r=41		

From this table a correlation of .41 was found by the Pearson formula between the teachers' estimates and the intelligence quotients. This is not high. There are several reasons for this fact. One prominent factor is the proportion of repeaters who have low intelligence quotients but because of greater age and previous experience are able to do good work. But the greatest fault is that for a good correlation the Pearson formula requires a similar distribution in the two sets of figures correlated. Reference to the total numbers of the various grades as assigned readily reveals the fact that the teachers' estimates do not provide a normal surface of distribution while the intelligence quotients are so distributed. The system of grading used in the schools does not fit the "normal probability curve."

CONCLUSIONS

The foregoing data suggest the following conclusions:

1. Tests of 183 first grade pupils show that their intelligence levels are distributed according to the normal curve. The repeaters over-weight the lower side. The beginners are evenly distributed on each side of 100 I. Q. as a median. The median of the repeaters is 90 I. Q.

2. The range of chronological and mental distribution is apparently as great here as at any stage of school life.

3. The mental age of these pupils is less homogeneous than the chronological, the chronological being distributed over five years of age and the mental over seven.

4. Pupils having I. Q.'s falling in the normal groups do not necessarily represent a homogeneous class from the pedagogical standpoint. The I. Q. is a means of individual rating. Mental age is more reliable for a group.

5. Pupils with an I. Q. above 100 are a more homogeneous group than those who fall below. These latter cannot be well handled in large classes. They must have individual study and instruction.

6. Pupils chronologically older do better work on the average, the chronological ages of both the mentally accelerated and the mentally at age or retarded decreasing steadily with the quality of school work.

7. If pupils have a lower I. Q. they must be chronologically older to do the same quality of school work; for example, in the whole group averaging 100 I. Q. and below and that 100.5 I. Q. and above, doing the same quality of school work, the difference in average chronological age is 7 months. For those groups doing satisfactory school work it is almost a year.

8. The quality of school work decreases with the mental age of the pupils.

9. Comparison of work accomplished by different rooms is unjust unless the chronological age, intelligence level, and proportion of repeaters are all taken into account first.

10. Age being relatively constant the quality of school work varies directly as the I. Q.

11. The average I. Q. of pupils between 6 and 7 years old is above 100. That of older pupils is below 100. This is the result of selection, many of these latter being laggards.

12. Beginning pupils doing A and B work are mentally slightly accelerated. C pupils are just at age. D and E pupils are slightly retarded.

13. A difference of 3.4 points was found in the average I. Q.'s of the two sexes, girls being slightly superior.

14. The correlation between the teachers' estimates of the quality of work done by the pupils and their I. Q.'s is .41. The fact that the two sets of figures are not similarly distributed is one factor tending to lower this figure. The inclusion of repeaters is another.

15. The number of feeble-minded and borderline cases show the need of a special class.

16. The number of pupils who would profit by an "opportunity" class is considerable.

17. Retardation begins in the first grade as a noticeable factor, 27.3% of these first grade pupils being retarded.

18. The fact that the average mental age of the repeaters is higher than that of the beginners shows pedagogical retardation. Better adjustment in this first year of school life is needed.

19. Pupils must be mentally 6 years old to do satisfactory first grade work.

20. Mental tests for entrance and classification of pupils would at least partly improve the situation existing among these first grade pupils.

The writer wishes to express her appreciation of the suggestions and assistance given in the pursuance of this study by Dr. B. W. DeBusk of the department of education of the University of Oregon, under whose direction it was carried out; by the faculty of the department of psychology; and by the teachers of the first grades in the public schools of Eugene.

Bibliography

Adler, Martha. Mental Test Used as a Basis for the Classification of School Children. *Jour. Ed. Psy.*, 1914, 5: 22-28.

Brooks, Robert P. A Study of the Slow and Over-Aged Child. *Ped. Sem.*, 1919, *26*: 49-55.

Cole, L. W. Mental Age and School Entrance. *Sch. and Soc.*, 1918, 8: 418-419.

Cuneo, Irene and Terman, Lewis M. Stanford-Binet Tests of 112 Kindergarten Children and 77 Repeated Tests. *Ped. Sem.*, 1918, 25: 414-428.

Hicks, Vinnie C. The Value of the Binet Mental Age Tests for First Grade Entrants. *Jour. Ed. Psy.*, 1915, 6: 157-166.

Kuhlmann, F. The Importance and Methods of Determining the Mental Age of Sub-Normal Children. *Proceedings* of 62d Annual Session, Wisconsin Teachers' Assn., 1914.

Terman, Lewis M., and Others. Stanford Revision Binet-Simon Scale. Warwick & York, Baltimore, 1917, 179 pp.

Terman, Lewis M. The Intelligence of School Childen. Houghton, Mifflin Co., Boston, New York, Chicago, 1919, 317 pp.

Terman, Lewis M. The Measurement of Intelligence. Houghton, Mifflin Co., Boston, New York, Chicago, 1916, 358 pp.

THE DEVELOPMENT OF CHILDREN BETWEEN THE AGES OF TWO AND SIX YEARS*

By Carl Schiotz

The following investigations were carried out with the assistance of the office in charge of adopted children (under the Kristiania Board of Health) through Miss L. Uchermann (Chief), Miss Signe Aasgaard, Mrs. Ruth Strom. The collection of data took place in May, 1919, through visits at nursing homes and asylums for children. A total number of 513 children, 264 boys and 249 girls were examined. Their distribution by age is seen from Table I. As "two-year-olds" were counted all that had completed their second, but not their third, year, hence the average age of such children is about 2½ years, etc. No selection was made except such as occurs naturally by the incidental absence of certain children on the day of visit, and by the objection of a small number of parents to the investigation of their children.

The material is being used here for two purposes: I, as a contribution to the study of the laws of development of children of the aforesaid groups; II, for the purpose of practical hygiene.

I. Contribution to the Study of the Laws of Development in Children between 2 and 6 Years

Foreign literature is rich in data on the development of school children and of infants, at least in regard to average relations, but a corresponding study of the ages here considered is relatively scanty.[1] From Sweden—considering Scan-

* This study by Dr. Schiötz originally appeared in the Norsk Magasin for Laegevidenskaben, May, 1920. Dr. Christian Bay's translation secured by the Bureau of Educational Experiments was made available for publication in the *Pedagogical Seminary* through the co-operation of the American-Scandinavian Foundation and the courtesy of Dr. A. G. Gade, Editor of the Norsk Magasin for Laegevidenskaben.

[1] Weissenberg (South Russian Jews); Variot-Chaumet (Paris); Camecasse (Paris, 4-14 years); Erismann (Russia); Heubner (Berlin); Camerer (Stuttgart); Puig i Roig (Barcelona); Bowditch (Massachusetts); Morgan-Rotch (Boston); Soley (Barcelona).

dinavia—only one series of investigations, by Tornell, in 1917, is on record, considering 285 children, of which 122 were under two years, the rest—163—from 2 up to and including 6; of these 82 were boys, 81 were girls.

The Anthropological Committee of Denmark, on the instigation of Poul Hertz, has undertaken measurements and weighing of institutional children in Copenhagen, in 1910-1911. Through the kindness of Dr. Hertz and Police Physician Soren Hansen I have been able to utilize the data concerning average height, weight and "ponderal index," from these studies. This material covers ages 1-12. Between the ages 2-6, 919 children (in 1910) and 1259 (in 1911) were examined. The final results of these investigations have not yet been published.

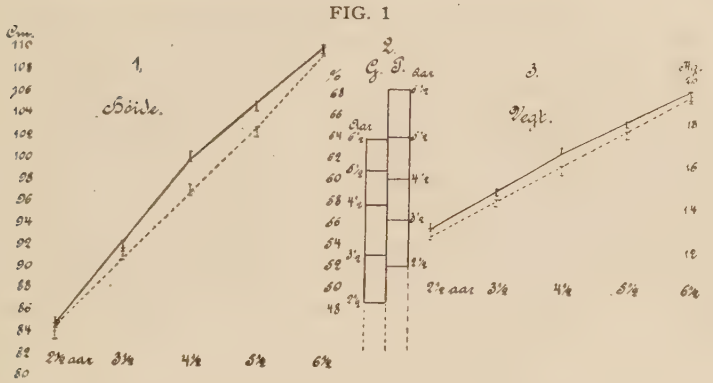
1. *Body Height*

Table 1 gives the statistical data from our material. This being limited, the conjectural sources of error may not be inconsiderable; it amounts to 4-5 millimeters for the averages, and 7 millimeters for one single class: 2 year girls. The averages in themselves are fairly good, but the increments from year to year are difficult to handle.

TABLE 1

Average Age	Number of Observations	Average Height cm.	Probable Errors	Difference with Standard cm.	Co-efficient of Variation	Probable Errors	Rounded-out Values: Aver. Height	Increase cm.	Increase %	Increase in Height, in % of Total Development
					Boys					
2½	40	84.82	±.46	4.35	5.13	±.39	84.5	...	...	...
3½	51	91.88	.46	4.84	5.27	.37	92.0	7.5	8.9	6.2
4½	51	100.27	.48	5.12	5.10	.34	100.0	8	8.7	6.7
5½	58	105	.45	5.12	4.89	.31	105.5	5.5	5.5	4.6
6½	64	110.37	.42	5.02	4.55	.27	110.5	5	4.7	4.2
					Girls					
2½	29	84.03	±.74	5.94	7.07	±.62	84.0	...	...	...
3½	50	91.20	.49	5.10	5.59	.38	91.0	7	8.3	6.4
4½	52	97.15	.50	5.31	5.47	.36	97.0	6	6.6	5.5
5½	61	102.63	.43	5.03	4.91	.30	103.0	6	6.2	5.5
9½	57	110.21	.41	4.63	4.20	.27	110.0	7	6.8	6.4

FIG. 1



Hoide = Height G = Gutte, Boys
Vegt = Weight P = Piker, Girls
——— = Boys
- - - - - = Girls

Fig. 1, curve no. 1, shows graphically a comparison of the average height of boys and girls—an approximately reasonable curve. The vertical lines indicate the average figures and their probable errors (cf., for this method of demonstration the Med. Revue, 1919, pp. 157-158). Foreign data uniformly show—this includes the aforesaid Swedish investigations—*greater bodily height in boys than in girls, in these groups of ages.* Our material yields a corresponding result. Owing to the general agreement on this point we may consider this sex-relation as a certainty, even though our material does not fulfill all demands of mathematical, statistical, correctness.

The " rounded-out " values of Table I designate the course of the curves read from millimeter paper and reduced to the nearest half-millimeter.

It will be of interest to compare these with the foreign results.

Table 2 shows a comparison with the aforesaid Danish investigations and with those of Tornell in Sweden. The latter were collected in the course of public vaccinations. Even though the source of error is greater in the Swedish figures, on account of the proportionately fewer number of individuals (9 to 31 in each year's class), the results still are worthy of attention considering that they show a large differ-

TABLE 2

HEIGHT IN CMS.

	Boys				*Girls*			
Age	Kristiania 1919	Copenhagen 1910–11	Norrtälje 1917	Paris	Kristiania 1919	Copenhagen 1910–11	Norrtälje 1917	Paris
2½	84.5	82.5	89.0	82.7	84.0	86.7	86.0	81.8
3½	92.0	91.2	96.0	89.1	91.0	92.5	94.0	88.4
4½	100.0	97.9	106.0	96.8	97.0	99.0	106.0	95.8
5½	105.5	102.3	110.0	103.3	103.0	104.5	109.0	106.9
6½	110.5	108.6	118.0	109.0	110.0	108.8	115.0	108.9

WEIGHT IN KILOS.

	Boys			*Girls*		
Age	Kristiania	Copenhagen	Norrtälje	Kristiania	Copenhagen	Norrtälje
2½	13.0	13.0	13.5	12.5	13.0	12.3
3½	15.0	14.7	14.7	14.5	14.7	13.1
4½	16.5	16.3	17.2	16.0	16.5	16.6
5½	18.0	17.4	18.9	17.5	18.1	17.4
6½	19.5	19.7	20.2	19.0	19.3	19.8

ence through all the various ages. This is in part explained by the uniformity of the social stratum from which the Kristiania data were drawn. The table also shows data closely related to those of Variot-Chaumet's Paris children.

A comparison between the Norwegian and the Danish results shows decided agreement as regards weights,—generally also for heights. A peculiar feature of the Danish studies is that girls of all ages are taller than boys, while the weights are equal for both sexes in 2-, 3-, and 4-year-olds and greater for boys at 6½; greater in girls at 5½.

In most studies we find that uniformly the body height is greater in boys than in girls, of the given groups. The weight relations show corresponding results. Are the boys of these classes thus more developed, or better developed? Conclusions of this kind have no logical foundation. The degree of development is not evident from these, or from similar, averages. In order to answer the question logically it is necessary to find out, for each age, how much each sex has attained of its specific development, e.g., how many per cent of the final specific development have been covered. Our material cannot give a true answer to this problem, because we do not know the exact average height for grown individuals

of the same category as is represented by our material. The error in this comparison between the sexes would, however, be very small, if we accept the ascertained averages for Norway: about 172 cm. for men and 160 cm. for women.

The graphic delineation Fig. 2 demonstrates how far the various classes have progressed in per cent of the final height. At 2½ years the boys (84.5 cm.) have attained about 49.1% of the final height (172 cm.). The girls have attained 84 cm., or 52.5%, of their final height (160 cm.). Thus, the girls of the given classes have attained considerably more of their height than do the boys. A girl of 5½ years would have attained as much height as a boy of 6½ years.

Weissenberg has published a detailed table of body height and various other body dimensions, figured according to this method.

The body height of a single child in itself permits of no conclusions concerning the total development of that individual. By total development we understand especially psychic development and development into an individual capable of propagation. In the calculation of averages, however, there is a distinct parallelism between average height on one side, and psychic development and puberty on the other. If a group of children at a given age shows great body height, it also shows a greater psychic development and eventually also a more advanced state of puberty than is found with individuals of equal age, but with a small development of body height. In a mass of material for children, the average body height may be considered an indicator of the total development, and therefore is of great importance. This fact was brought out in two previous studies (17) and by an investigation at Stavanger in 1918 (19).

Note.—For an (objective) judgment of the physical stage of development of individual children, certain relations between the body height and the ossification of the skeleton (e.g., roentgenographs of the hand) undoubtedly are the best criteria. For older children, data are to be adduced from the signs of puberty and the secondary sexual characteristics.

From this we proceed to the study of the growth from one year to another. Here we again must point out that the calculation of averages in centimeters and kilos certainly is of practical importance in the comparison of individuals and in the checking up of selected ones,—but for a study of the laws of growth these absolute figures are quite useless. A

study of growth presupposes certain co-efficients. Two methods may be considered:

How much increase does a child (or the year-class of children) show in proportion to the final development (e.g., at the age of 7-8 years perhaps 3.2% of the height attained at the age of 7)? Only this figure will give a true expression of the growth-energy and makes real comparisons possible, so that the laws of growth can be inquired into, for the two sexes, for various ages, for different races—and even for a comparison of various classes of animals. These co-efficients are of a far greater biological interest than the (arbitrary and) absolute units of measurement. Even direct comparisons of the increases in weight and height become possible. Thus, girls at 13½-14½ years—height increase 4%, weight increase 14.3% (of the figures at 13½ years). It is evident that these figures allow a far deeper insight into the biological relations than the absolute figures[2]—6 cm. and 5.5 kilos—ever would. Again, boys, 14½-15½ years, weight increase 18%; girls of same age 9%. The absolute figures yield no useful comparison of the biological relation or of the energy of development, because they do not permit a consideration of the initial figures—the weight of 14-year-olds—upon which the relation really rests.

Regarding once more our own material, we already have made it clear that the probable errors in the averages render a mathematically correct calculation of increases impossible. A closely approximated calculation is found in Table 1. We do not consider closely the absolute values, or the increases in cms., because they allow of no intelligent conclusions in regard to the energy of growth. (On the contrary, these values might lead to the belief that the growth for boys about 4 years—i.e., from 3½ to 4½ years—is greater than it is at about 3 years.) While small errors occur in the decimals, we still observe that the per cent of increase, the growth-energy, in boys at these ages (3-6 years) is very greatly decreasing, namely, from about 9% about their third birthday to about 4½ at their sixth birthday: a decrease of nearly one-half. Boys are the strongly-growing sex at the ages between 2½ and 4½; during the following two years this relation is reversed.

[2] None of these have been used in the better known works on growth relations (Key and Weissenberg; a new and very large work by Demoor, etc.). Friedenthal considers only the growth in percentage. W. Kiorgaard applied successfully his data concerning percentage of growth increases in children's sanitoria in Copenhagen and its surroundings.

We mentioned that the co-efficient of increase—a good term introduced by Spitzy (who brings no tables, however, developed on this principle)—makes it possible to compare widely different ages. Figures as high as 8% per annum—2½-4½ year boys—are not attained at any subsequent age in life. The values for 4½-6½ year boys (5½ and 4½%) designate the beginning of the transition to the relatively lower figures characteristic for the years of attendance at school (about 3.3%)[3]—and are attained only once in later life, namely, during the years of greatest growth-increase during the period of pre-puberty, about the fifteenth birthday (5½%). Thus, the growth-energy of the age 2½ to 4½ years is twice that of the years of school attendance. The growth of the period 4½-5½ years corresponds to that of 14½-15½, or ten years later. The values for girls at the ages 2½-6½ (always above 6%) never is attained later in life, as the period of pre-puberty never shows figures as high as 5%.

The variation in height among the individuals—expressed as a co-efficient of variation—also is seen at Table I. The figures vary generally between slightly above 4 and slightly above 5 and are greater in the younger classes—and descending when the years of school attendance are reached, at which previous investigations, both of girls and of boys, have shown a figure of a little above 4, with an increase toward the period of pre-puberty (above 5), followed by a rapid decrease. During the years of strong development a great difference is found amongst the individuals of each year-class. Naturally, a difference in age of one year (between the youngest and the eldest child of a year-class, must result in a greater difference in height between the younger and the elder children, when normally the growth during the same year is intense. This, however, does not in itself explain the phenomenon; if so, the variations found during the years of very intense growth—2½-4½ years—would be much greater than during pre-puberty, when the growth is less strong. But this certainly is not the case with the boys.

Another factor might serve to explain the great variations during the years of intense growth. The supposition is not unreasonable, that the mutual differences in living conditions and influences will be felt very decidedly during the years of intense development. Inherited peculiarities also might exert some influence.

[3] Previously published investigations. Certain minor errors, due to the unevenness of the material, will not disturb the total value of a given series in any appreciable way.

The second method in calculating increases in growth—not useful, however, in illustrating the *energy* of growth from year to year, because there we always must consider the initial height, the height of the youngest child—must develop as a reply to the following question: How great a portion of the total growth from newborn to fullgrown is accomplished during a certain year? If we look once more at Table 1 (at the right), we find this to be, for boys during the whole period of 2½-6½, 21.7%; for girls, 23.8%. (The figures for newborn children were derived from data collected by Marie Kjolseth; as normals for fullgrown we take 172 cm. and 160 cm.)

All in all, our study of the laws of growth (co-efficient of growth, etc.) makes evident that *there is a pronounced biological difference between girls and boys also during their early years of life.* Such terms as "a sexual period" in contradistinction to the "bisexual," which was supposed to begin some time previous to puberty, must be abandoned as wholly unscientific and moreover as unpractical. Spitzy et al. talk about a "neutral period" as between 2 and 7; a "bisexual" period between 8 and 15. Why from the eighth year?

TABLE 3

Age	No. of Individuals	Aver. Wt. Kilos.	Probable Errors	Variation From Standards Kilos.	Co-efficient of Variation	Probable Errors	Rounded-out Values Weight Kilos.	Increase Kilos.	Increase %
				Boys					
2½	40	13.09	±.16	1.52	11.61	±.89	13.0	...	...
3½	51	14.75	.17	1.76	11.93	.81	15.0	2.0	15.4
4½	51	16.70	.15	1.62	9.70	.65	16.5	1.5	10.0
5½	58	17.96	.17	1.91	10.64	.75	18.0	1.5	9.1
6½	64	19.32	.17	1.96	10.15	.66	19.5	1.5	8.3
				Girls					
2½	29	12.74	±.26	2.11	16.60	±.55	12.5	...	....
3½	50	14.23	.17	1.86	13.07	.90	14.5	2.0	16.0
4½	52	15.79	.19	2.04	12.93	.87	16.0	1.5	10.3
5½	61	17.44	.17	2.02	11.56	.73	17.5	1.5	9.4
6½	57	19.14	.17	1.94	10.02	.65	19.0	1.5	8.6

2. *Body Weight.* Compare Table 3 and Fig. 1 (curve 3)[4]

An increase from 13 to 19.5 kilos in boys, from 12.5 to 19 kilos in girls. The increase—percentage—uniformly is greater in girls than in boys, and for both sexes decreasing down to about one-half. The averages for body weight, as aforesaid, are greater in boys. The percentages of growth-increase are considerably greater than those of height increase,

[4] Comparison with Tornell's Swedish results, *vide* Table 2.

e.g., boys (2½-4½ years), height-increase 8.9%, weight-increase 15.4%. But while height-increases of more than 8% was not attained later in life, boys of the period of prepuberty attain greater values for weight-increase than during their early age (in my Kristiania material, 17.9% in boys of 14½-15½ years, but not in girls).

A comparison with Tornell's Swedish figures shows in general—yet there are some exceptions—lower figures for Kristiania children than for Swedish children.

The variation in body weight—calculated as variation-coefficient—averages twice that in height. A study of the ages 12-17 in Kristiania showed the weight-variation to be even three times that of height-variation. The weight-variations brought out in our material do not reach what we found in boys at the ages 13-16.

Finally, not the least important problem to be considered is the weight-height relation calculated as a "space-index"—the weight, in percentage, of a cube whose edge equals the body height, the relation as follows: $\frac{\text{Weight X100.}}{\text{Height}^3}$ Compare *Med. Revue,* 1919, April.

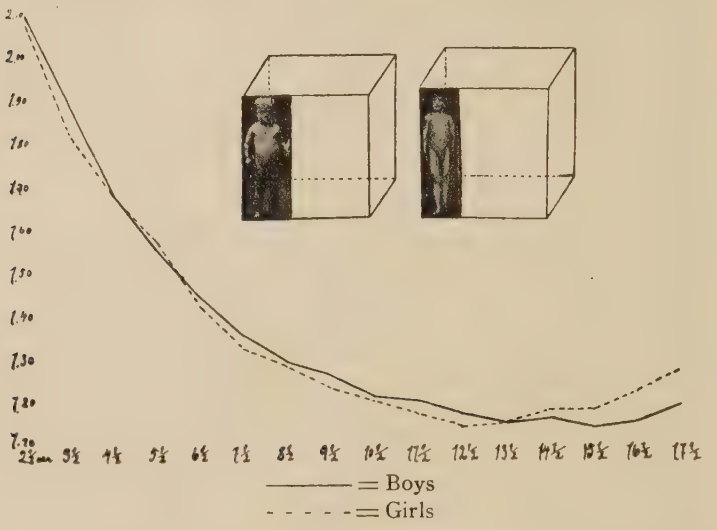
3. *The Weight-Height Relations of the Body*

The space index has been determined for each child; the averages for each year-class are seen in Table 4 and have been expressed graphically in the curve in Fig. 2, which also contains averages of the material dating from May and November, 1919.

TABLE 4

Age	"Space Index"	Probable Errors	Variation From Standard	Co-efficient of Variation	Probable Errors	Index Rounded-out Values
			Boys			
2½	2.13	±.022	.20	9.63	±.73	2.13
3½	1.91	.018	.19	9.55	.64	1.90
4½	1.66	.018	.18	10.92	.73	1.67
5½	1.55	.014	.16	10.19	.65	1.54
6½	1.45	.012	.14	9.76	.58	1.44
			Girls			
2½	2.13	±.031	.25	11.96	±.94	2.13
3½	1.87	.018	.19	10.13	.78	1.89
4½	1.73	.017	.18	10.61	.71	1.73
5½	1.61	.016	.18	11.18	.70	1.60
6½	1.41	.013	.14	10.01	.64	1.41

FIG. 2



The curve, developed from calculations of averages of the May and November-results shows for ages 2-6 uniformly a greater weight-height value for boys than for girls, excepting the class 5 where the girls show a slightly higher figure. In class 4 there was no difference. The remainder of the curve, to be discussed later, also shows a higher figure for the boys, up to and including class 12. Therefore, it is a question whether year 5 should be considered a valid exception. That the girls show a considerably lower weight-height relation than the boys, in all these years, may rather with certainty be referred to their relatively more rapid development. About the twelfth year is the period of the strong puberty growth in height of girls, after which period the growth takes a more quiet course, and then the weight-height values increase until at the point of class 12 it exceeds those of the boys.

The calculated average for the space-index demonstrates very plainly the very intense decrease of weight in proportion to height which is found during the infancy period of 2½ to 6½ years—from an index for 2 year boys of 2.13 to the value of 1.44 (=68% of the figure at 2 years) at 6 years—for girls, from 2.13 at 2 years to 1.41 (66%) at 6 years.

The variation in body-space is very great—the coefficient on the average about 10. It should be observed, however,

that girls—pupils at the communal schools in Kristiania—of the age 13-16 show an equally great variation individually, but this is not true of boys of the same age.

We shall add here some remarks on the methods used in calculating the weight-height relation, Rohrer's "Index der Korperfulle." A glance at the photographs of the average types of 2 year olds and of 6 year olds (Figs. 3a and b), the slenderness of the latter, as compared with the former, is very evident—a fact otherwise so well authenticated that no further demonstration is necessary. This relation, of course, is still more evident by comparing the 2 year old with the 11 year old.

Although the body-total, considered through observation of outward relations, will not find an adequate descriptive expression in the weight-height relation, it still remains true that there is a high degree of parallelism between these features, and consequently we may expect that a method aimed as a calculation of weight-height relations will show strongly decreasing averages from 2 year olds to 6 year olds and further to 11 year olds. If this were not so, the usefulness of the method might well be subject of strong doubt. Rohrer's weight-height index shows for boys of 2½ to 6½ years, a decrease from 2.13 to 1.44; for girls, from 2.13 to 1.41.

Another method is Livi's "ponderal index." The aforesaid Danish tables, kindly placed at my disposal, gives averages for height and weight—the results of these, the first measurements taken in Scandinavia from children of tender age—and these data are especially valuable because they still form the largest bulk of Scandinavian material on these lines of research. They also contain a calculation of Livi's ponderal index.[6] This shows for boys of 2 years in 1910 .0274 (same in 1911), for 6 years .0249 (same in 1911); for 2 year girls .0271 (.0272 in 1911), and for 6 year girls .0247 (.0246 in 1911). Thus, this method demonstrates but very imperfectly the undoubtedly very considerable decrease in weight in proportion to height.

A certain bulk of material investigated by rational methods and considered as a status praesens at a given period of time, always possesses the interest of adding to the knowledge of the investigator—perhaps also of others. Thus far we have considered our results as a contribution to our knowledge of the growth relations for the ages of childhood under consid-

[6] $\frac{\sqrt[3]{\text{weight}}}{\text{height}}$

eration. The material being rather uniform, perhaps even one sided, it still adds to our knowledge of the development of children of the given milieu. It must be remembered that the averages *from a highly differentiated material* MAY render the true interpretation of the laws of development obscure. A certain portion of material may exemplify a rather strong development, while another portion may represent a weaker development. The averages may yield a rather neutral result, which in reality fails to characterize any one distinctive component group of the total material.

Our results, however, are so closely in harmony with those of other countries that our conclusions—especially those concerning a comparison between the two sexes—certainly are capable of a wide generalization. This, of course, renders the material more valuable for the general purpose of a study of the laws of growth in general.

We here take leave of the " theoretical " studies of growth. The problem before us—concerning, as it does, not only the physician but also the practical hygienist—is whether these investigations may assist in *bettering any actual conditions.* First we shall view our material in its usefulness as a possible means of comparing or judging the physical status of children of these ages. Such material is greatly needed, inasmuch as no other Norwegian material is at hand, and other Scandinavian work in the same line is scanty. Secondly, we shall report on the material from its aspects as the means of affording a hygienic control of the children represented in our data.

II. The Practical Utilization of Our Material

Even with the most severe restrictions we are obliged for the present to admit that our data will serve as a normal exposé of investigations at spring time,[7] of conditions as they exist among a population which makes systematic use of a day nursery or a children's asylum.

A. How far the results are applicable beyond this social group, we shall try to investigate in the following pages. So far as the average, or medium, heights are concerned, we may suppose them somewhat too low to be considered normal for Norway or even for Kristiania, on account of the material having been extracted from a one-sided stratum and representing only a socially less opulent class.

[7] The material was collected in the month of May

A similar consideration may be applied to the values for absolute weight. These absolute weights, however, are—apart from those of the first two years of life and especially of infancy—of less interest for the problems now considered in view of the body-height and the relation of weight-height. Strongly characteristic of the material at hand is the relation of body height to weight, weight-height index. This leads us to the question whether the results for the weight-height relation may be used outside of the given social class. For the purpose of deciding this we present a group of average types for each year-class (Figs. 3a and 3b). (The communication of the investigator's "impression" or even of his "most decided impression" of the quality of his material, counts for nothing; it no longer interests me, nor do I ask any such interest of others.)[8]

No attempt has been made to select faultless children in these groups. Rachitic individuals are partly distinguishable. The selection was made from the slips bearing previously recorded data, and from these slips the children were selected for inclusion in the groups to be photographed. The recorded height of the photographed children average .5 cm., their weight .6 kilo and—which is of greater importance—their weight-height index but .005 from the average values for the individual sex and ages. The height, weight and height-weight index is given for each child and from each sex the same data for each group, for comparison with the averages. Curves also have been constructed, from which we see that the photographed children generally are slightly "lighter" than the medium value for the year-classes, excepting the 4 year boys, the one 2 year girl who is slightly heavier, and 5 year girls who are stationed exactly on the average.

In spite of the generally too low weight-height values the photographs will be found indicating a rather better nutritive condition in the children than one might expect. Even though nutrition and hygienic provisions at the nurseries might be supposed quite satisfactory (although they naturally are not equally good at all of them), it must be remembered that many children have been under their care only for a very short time—two of the nurseries are but provisional stations for children—and therefore can show no definite improvement. In considering the day nurseries account must be taken of the relatively long sojourn of the children at their homes (at night, on holidays and during long vacations),

[8] On June 1st.

FIG. 3a

	Height Cm.	Weight Kilos.	H.-W. Index
2 Year Olds			
B. Aver.	84.5	13.0	2.13
B. Photo	84.5	12.4	2.05
G. Aver.	84.0	12.5	2.13
G. Photo	83.3	13.0	2.20
3 Year Olds			
B. Aver.	92.0	15.0	1.90
B. Photo	92.5	14.5	1.84
G. Aver.	91.0	14.5	1.89
G. Photo	91.3	14.2	1.87
4 Year Olds			
B. Aver.	100.0	16.5	1.67
B. Photo	100.3	17.4	1.72
G. Aver.	97.0	15.0	1.73
G. Photo	97.1	15.3	1.67

Height Cm.	Weight Kilos.	H.-W. Index
2 Year Olds		
83.3	13.0	2.20
84.8	12.9	2.12
84.1	12.2	2.05
84.6	12.2	2.01
3 Year Olds		
92.3	14.2	1.81
92.7	14.8	1.86
91.2	13.9	1.83
91.4	14.5	1.90
4 Year Olds		
101.0	17.2	1.67
99.4	17.2	1.75
100.5	17.7	1.74
100.4	17.5	1.73
97.4	15.1	1.63
96.2	15.3	....
97.6	15.4	1.72
....	....	1.66

B = Boys; G = Girls.
Aver. = Average values of the whole material.
Photo = " " of the group in the photograph.

FIG. 3b

		Height Cm.	Weight Kilos	H.-W. Index
	5 YEAR OLDS			
B.	Aver.	105.5	18.0	1.54
	Photo	105.7	17.8	1.51
G.	Aver.	103.0	17.5	1.60
	Photo	102.5	17.1	1.60
	6 YEAR OLDS			
B.	Aver.	110.5	19.5	1.44
	Photo	110.5	19.2	1.42
G.	Aver.	110.0	19.0	1.41
	Photo	110.9	18.9	1.39

5 aar

6 aar

		Height Cm.	Weight Kilos.	H.-W. Index
	5 YEAR OLDS			
		105.8	18.3	1.55
		105.5	17.2	1.46
		102.1	17.1	1.61
		102.7	18.1	1.67
		102.3	16.4	1.53
		101.9	17.6	1.66
		102.6	16.4	1.52
		103.2	17.7	1.61
	6 YEAR OLDS			
		109.8	20.2	1.53
		111.1	18.7	1.36
		110.7	18.7	1.38
		111.2	19.2	1.40
		110.5	18.5	1.38

B = Boys; G = Girls.
Aver. = Average values of the whole material.
Photo = " " of the group in the photograph.

where neither the housing conditions nor nutritive provisions can be expected to be rationally provided for. But even so, the nutritive condition of the children generally was better than expected. It must be remembered, however, that conclusions of this kind may lead to an error—a rather interesting error not discovered immediately. *Children from socially better conditioned homes, of the same ages as those shown in our photographs, generally will have attained a better total development, but in so doing they also will have progressed farther in their physiological emaciation*—compare the decided lowering of the index from year to year. Hence, *the satisfactory average nutritive condition of the children recorded here is due in part to a relatively slower development than will be met in children from a better social stratum.*[10]

Thus we find that the descent of the children introduces a factor which affects their development unfavorably. But the same unfavorable factor again is responsible for a more retarded physiological emaciation. The result is that the recorded values for weight-height must not—as is the case with the averages for body height—be considered absolutely too low to serve as workable normal values; especially not when use is made of the calculated standard records for variations. Example: A remarkably low weight-height record for a 2½ year boy below 1.93,[11] or a remarkably high record above 2.33.[12] Between 1.93 and 2.33: this is no difference involving any practical difficulty.

It seems not necessary to emphasize the aforesaid error in the estimation of the children, because this error impends as soon as one attempts to judge the "nutritive conditions" without considering whether the physiological development—and with this, the physiological emaciation—occupies a primitive state in comparison with the age of the individual. An objective judgment of the somatic development must consider the previously mentioned condition of ossification together with the body height and, in later years, the signs of puberty. Pfaundler, in a paper concerning the conditions of school children, mentions that while children of the socially well-to-do generally are taller than those of the less opulent classes, this advantage is of doubtful value, because generally their weight is lower in proportion to this increased height. Our data confirm this conclusion fully. The comparatively

[10] Comp. Törnell's Swedish records (table 2)—a much better body height, while the weight values do not show a constant elevation.

[11] 2.13 (average) less .20 (deviation from standard), cf. tab. 4.

[12] 2.13 + .20.

rapid total development induces a greater average height of body together with a more rapid physiological emaciation.[13] In spite of this fact it is true that the resistance against disease is greater among the opulent. Pfaundler makes mention of a one-sidedly accelerated development in height among children of the opulent, but this cannot be accepted without some qualification. The development is a total development, and the physiological emaciation is but one feature of that. This view is further supported by the fact that menstruation generally begins at an earlier period among the opulent classes —a fact also mentioned by Pfaundler. This author does not overlook the significance of the physiological emaciation in the development of the opulent as compared with the less opulent. But he accords to it a subordinate significance: "perhaps the following . . . may contribute" (whereupon the said relation is mentioned). This "perhaps" should be changed to a "*certainly.*"

When Samosch, Rietz, and others, refer to the relative circumference of the chest, and call attention to the fact that the opulent classes are less favored in this respect, the following consideration must be imposed: It is true that the relative chest circumference decreases physiologically in a line ascending with age (for boys up to the age of 13-15, whereupon an increase sets in, according to my investigations). Individuals physiologically farther developed (e.g., the average of the opulent compared with that of the less opulent), therefore, generally will demonstrate a relatively less chest circumference up to the aforesaid ages.

The relation here considered, namely, the dependence of the nutritive condition—or, rather, of the weight-height relation—upon the stage of general development, certainly must be considered an important component factor in that relation which quite empirically seems evident to everybody: that tall children, irrespective of descent and surroundings, generally are somewhat thin, while short ones are generally more rotund.

This completes the use of our statistical records of 2-6 year-olds, except for one important relation left for consideration until now. The Tables 1-4 are concerned with entire year-classes, average values and variation relations. The development in these tender years progresses, however, very rapidly (comp. the strong increase for both weight and height, the rapid falling of the weight-height index). The tables for year-classes covering these ages become rather too full of

[13] This physiological emaciation generally is succeeded by an increase in the weight-height relation, in boys at 15½ yrs., in girls at 12½ yrs.

errors (owing to the variability of the material), and while recognizing these, one should not be so modest in his demands that "sufficiently exact for clinical use" should constitute one's standard of exactness.

For this reason, the calculations should be extended to each month of these tender years. This would necessitate an enormous work with statistical calculations of averages, etc., or it would be necessary to submit the entire material to a continued investigation from month to month for a whole year. To do this is a hope for the future, when we may expect to have an organized medical supervision of all nurseries and similar institutions, which at present are largely or wholly dependent on philanthropy, and often are hard pushed economically. To the demands upon such an organized medical supervision also pertains, in my opinion, an objective and subjective control of each individual child. This is being carried out at one of the institutions furnishing material for our investigation, but in order to make use of these data they should be extended to all the material uniformly.

A greater correctness in our records may, however, be attained on the basis of what data we have. Boys between 3 and 4 years old and examined in May, 1919, had attained an average height of 92 cm. This figure characterizes best the age of 3½; for 4½ year olds we have the record of 100 cm., for 5½ 105.5 cm. These data may now be connected into a curve by the use of millimeter paper. The distance between the figures for each year-class being arranged on the abscissa so as to be easily divided by 12, the approximate values for each month (thus, 3 years 7 months; 3 years 8 months, etc.) may be easily worked out. These values—averages for practical use, for height, weight, and weight-height index—have been tabulated on Table 5. They have been carried out on the basis of the May as well as the November investigations, in order to represent better the all-year results. To determine the standard variation similarly would necessitate a continued observation during the whole year, hence cannot be developed from the material presented here. The variation given in our table refers to the year-class in closest proximity to each month of full age, hence these values represent no scientifically exact statistic calculation, but merely a practical interval which is in accord with biologial truth in so far as the data are based on the characteristics of the *closest* year-class.[14]

[14] But not of each month. The standard variation for 2-3 yrs., for 3-4 yrs., etc., has been arranged in curves and calculated for months as above.

TABLE 5A

AVERAGES FROM INVESTIGATIONS IN MAY AND NOVEMBER, 1919

Boys

Age		Height			Weight			Weight—Height Index		
Yrs.	Months	Average Cm.		Standard Variation	Average		Standard Variation	Average		Standard Variation
2	6	86.0	4.1	81.9– 90.1	13.3	1.7	11.6–15.0	2.09	.18	1.91–2.27
	7	86.5	4.2	82.3– 90.7	13.4	...	11.7–15.1	2.07	...	1.89–2.25
	8	87.0	...	82.8– 91.2	13.6	...	11.9–15.3	2.05	...	1.87–2.23
	9	87.5	4.3	83.3– 91.8	13.7	...	12.0–15.4	2.04	...	1.86–2.22
	10	88.0	...	83.7– 92.3	13.8	...	12.1–15.5	2.02	...	1.84–2.20
	11	88.6	...	84.3– 92.9	13.9	...	12.2–15.6	2.01	...	1.83–2.19
3	0	89.1	4.4	84.7– 93.5	14.1	...	12.4–15.8	1.99	...	1.81–2.17
	1	89.7	...	85.3– 94.1	14.2	...	12.5–15.9	1.97	...	1.79–2.15
	2	90.2	4.5	85.7– 94.7	14.3	...	12.6–16.0	1.96	...	1.78–2.14
	3	90.7	...	86.2– 95.2	14.4	1.6	12.8–16.0	1.94	...	1.76–2.12
	4	91.2	...	86.7– 95.7	14.6	...	13.0–16.2	1.92	...	1.74–2.10
	5	91.7	4.6	87.1– 96.3	14.7	...	13.1–16.3	1.91	...	1.73–2.09
	6	92.2	...	87.6– 96.8	14.8	...	13.2–16.4	1.89	...	1.71–2.07
	7	92.8	4.7	88.1– 97.5	14.9	...	13.3–16.5	1.87	...	1.69–2.05
	8	93.5	...	88.8– 98.2	15.1	...	13.5–16.7	1.85	...	1.67–2.03
	9	94.1	...	89.4– 98.8	15.2	1.7	13.5–16.9	1.84	...	1.66–2.02
	10	94.7	4.8	89.9– 99.5	15.4	...	13.7–17.1	1.82	...	1.64–2.00
	11	95.3	...	90.5–100.1	15.5	...	13.8–17.2	1.80	...	1.62–1.98
4	0	95.9	4.9	91.0–100.8	15.7	...	14.0–17.4	1.78	...	1.60–1.96
	1	96.5	...	96.1–101.4	15.8	...	14.1–17.5	1.77	...	1.59–1.95
	2	97.1	...	92.2–102.0	16.0	...	14.3–17.7	1.76	...	1.57–1.93
	3	97.8	5.0	92.8–102.8	16.1	...	14.4–17.8	1.73	...	1.55–1.91
	4	98.4	...	93.4–103.4	16.3	...	14.6–18.0	1.72	...	1.54–1.90
	5	99.0	...	94.0–104.0	16.4	...	14.7–18.1	1.70	...	1.52–1.88
	6	99.7	5.1	94.6–104.8	16.6	...	14.9–18.3	1.68	...	1.50–1.86
	7	100.1	...	95.0–105.2	16.7	...	15.0–18.4	1.67	...	1.49–1.85
	8	100.6	...	95.5–105.7	16.8	...	15.1–18.5	1.66	...	1.48–1.84
	9	101.0	5.0	96.0–106.0	16.9	...	15.2–18.6	1.65	.17	1.48–1.82
	10	101.5	...	96.5–106.5	17.0	...	15.3–18.7	1.64	...	1.47–1.81
	11	101.9	...	96.9–106.9	17.1	...	15.4–18.8	1.63	...	1.46–1.80
5	0	102.4	...	97.4–107.4	17.3	...	15.6–18.9	1.62	...	1.45–1.79
	1	102.8	...	97.8–107.8	17.4	...	15.7–19.1	1.61	.16	1.45–1.77
	2	103.3	...	98.3–108.3	17.5	...	15.8–19.2	1.59	...	1.43–1.75
	3	103.7	4.9	98.8–108.6	17.6	...	15.9–19.3	1.58	...	1.42–1.74
	4	104.2	...	99.3–109.1	17.7	...	16.0–19.4	1.57	...	1.41–1.73
	5	104.6	...	99.7–109.5	17.8	...	16.1–19.5	1.56	.15	1.41–1.73
	6	105.1	...	100.2–110.0	17.9	...	16.2–19.6	1.55	...	1.40–1.70
	7	105.5	...	100.6–110.4	18.0	1.8	16.2–19.8	1.54	...	1.39–1.69
	8	106.0	...	101.9–110.9	18.1	...	16.3–19.9	1.53	...	1.38–1.68
	9	106.4	...	101.5–111.3	18.3	...	16.5–20.1	1.52	...	1.37–1.67
	10	106.9	...	102.0–111.8	18.4	...	16.6–20.2	1.52	...	1.37–1.67
	11	107.3	...	102.4–112.2	18.5	...	16.7–20.3	1.51	...	1.36–1.66
6	0	107.8	...	102.9–112.7	18.6	1.9	16.7–20.5	1.50	...	1.35–1.65
	1	108.3	...	103.4–113.2	18.8	...	16.9–20.7	1.49	.14	1.35–1.63
	2	108.7	4.8	103.9–113.5	18.9	...	17.0–20.8	1.48	...	1.34–1.62
	3	109.2	...	104.4–114.0	19.0	...	17.1–20.9	1.47	...	1.33–1.61
	4	109.6	...	104.8–114.4	19.1	...	17.2–21.1	1.47	...	1.33–1.61
	5	110.1	...	105.3–114.9	19.3	2.0	17.3–21.3	1.46	...	1.32–1.60
	6	110.6	...	105.8–115.4	19.4	...	17.4–21.4	1.45	...	1.31–1.59

TABLE 5B

AVERAGES FROM INVESTIGATIONS IN MAY AND NOVEMBER, 1919

Girls

Age		Height			Weight			Weight—Height Index		
Yrs.	Months	Average		Standard Variation	Average		Standard Variation	Average		Standard Variation
2	6	85.2	5.1	80.1– 90.3	12.7	1.9	10.8–14.6	2.07	.20	1.87–2.27
	7	85.8	...	80.7– 90.9	12.8	...	10.9–14.7	2.05	...	1.85–2.25
	8	86.4	...	81.3– 91.5	13.0	...	11.1–14.9	2.03	...	1.83–2.23
	9	87.0	...	81.9– 92.1	13.1	...	11.2–15.0	2.01	...	1.81–2.21
	10	87.6	...	82.5– 92.7	13.2	1.8	11.4–15.0	1.98	...	1.78–2.18
	11	88.1	...	83.0– 93.2	13.4	...	11.6–15.2	1.96	...	1.76–2.16
3	0	88.7	...	83.6– 93.8	13.5	...	11.7–15.3	1.94	...	1.74–2.14
	1	89.3	...	84.2– 94.4	13.7	...	11.9–15.5	1.92	.19	1.73–2.11
	2	89.9	5.2	84.7– 95.1	13.8	...	12.0–15.6	1.90	...	1.71–2.09
	3	90.5	...	85.3– 95.7	14.0	...	12.2–15.8	1.88	...	1.69–2.07
	4	91.1	...	85.9– 96.3	14.1	1.7	12.4–15.8	1.86	...	1.67–2.05
	5	91.7	...	86.5– 96.9	14.3	...	12.6–16.0	1.83	...	1.64–2.02
	6	92.2	...	87.0– 97.4	14.4	...	12.7–16.1	1.81	...	1.62–2.00
	7	92.7	...	87.5– 97.9	14.5	...	12.8–16.2	1.81	...	1.62–2.00
	8	93.2	...	88.0– 98.4	14.6	1.8	12.8–16.4	1.80	...	1.61–1.99
	9	93.7	5.1	88.6– 98.8	14.7	...	12.9–16.5	1.79	.18	1.61–1.97
	10	94.2	...	89.1– 99.3	14.9	...	13.1–16.7	1.78	...	1.60–1.96
	11	94.6	...	89.5– 99.7	15.0	...	13.2–16.8	1.76	...	1.58–1.94
4	0	95.1	...	90.0–100.2	15.1	1.9	13.2–17.0	1.75	...	1.57–1.93
	1	95.6	...	90.5–100.7	15.2	...	13.3–17.1	1.74	...	1.56–1.92
	2	96.1	...	91.0–101.2	15.3	...	13.4–17.2	1.73	...	1.55–1.91
	3	96.5	5.0	91.5–101.5	15.5	...	13.6–17.4	1.72	...	1.54–1.90
	4	97.0	...	92.0–102.0	15.6	...	13.7–17.5	1.71	.17	1.54–1.88
	5	97.5	...	92.5–102.5	15.7	2.0	13.7–17.7	1.70	...	1.53–1.87
	6	98.0	...	93.0–103.0	15.8	...	13.8–17.8	1.68	...	1.51–1.85
	7	98.5	...	93.5–103.5	15.9	...	13.9–17.9	1.67	...	1.50–1.84
	8	99.0	...	94.0–104.0	16.1	...	14.1–18.1	1.66	...	1.49–1.83
	9	99.5	4.9	94.5–104.4	16.3	...	14.3–18.3	1.65	...	1.48–1.82
	10	100.0	...	95.1–104.9	16.4	...	14.4–18.4	1.64	...	1.47–1.81
	11	100.5	...	95.6–105.4	16.6	...	14.6–18.6	1.63	...	1.46–1.80
5	0	101.0	...	96.1–105.9	16.7	...	14.7–18.7	1.62	...	1.45–1.79
	1	101.4	...	96.5–106.3	16.9	...	14.9–18.9	1.61	...	1.44–1.78
	2	101.9	...	97.0–106.8	17.0	...	15.0–19.0	1.60	...	1.43–1.77
	3	102.4	...	97.5–107.3	17.2	...	15.2–19.2	1.59	...	1.42–1.76
	4	102.9	4.8	98.1–107.7	17.3	...	15.3–19.3	1.59	...	1.42–1.76
	5	103.4	...	98.6–108.2	17.4	...	15.4–19.4	1.58	...	1.41–1.75
	6	103.9	...	99.1–108.7	17.6	...	15.6–19.6	1.57	...	1.40–1.74
	7	104.4	...	99.6–109.2	17.7	...	15.7–19.7	1.56	...	1.39–1.73
	8	105.0	...	100.2–109.8	17.9	...	15.9–19.9	1.54	...	1.37–1.71
	9	105.5	...	100.7–110.3	18.0	...	16.0–20.0	1.53	.16	1.37–1.69
	10	106.0	...	101.2–110.8	18.1	...	16.1–20.1	1.52	...	1.36–1.68
	11	106.6	4.7	101.9–111.3	18.3	...	16.3–20.3	1.51	...	1.35–1.67
6	0	107.0	...	102.4–111.8	18.4	...	16.4–20.4	1.49	...	1.33–1.65
	1	107.6	...	102.9–112.3	18.5	...	16.5–20.5	1.48	.15	1.33–1.63
	2	108.2	...	103.5–112.9	18.7	2.1	16.6–20.8	1.47	...	1.32–1.62
	3	108.7	...	104.0–113.4	18.8	...	16.7–20.9	1.46	...	1.31–1.61
	4	109.2	...	104.5–113.9	19.0	...	16.9–21.1	1.44	...	1.29–1.59
	5	109.7	...	105.0–114.4	19.1	...	17.0–21.2	1.43	.14	1.29–1.57
	6	110.3	...	105.6–115.0	19.2	...	17.1–21.3	1.42	...	1.28–1.56

This is true especially for the weight-height index where the variation within the given years is very considerable, and the variation, or difference, between the individuals mutually grows less and less (2 year olds have a stand.-var. of .18 decreasing to .14 in 6 year olds, for boys; girls, .20 decreasing to .14). Yet this practical interval becomes fairly spacious; values above or below the limits show considerable variation from the standards. This is of interest in so far as only variations of some size possess any clinical interest. On the other hand, the limits are neither arbitrary nor by any means unduly spacious.[15] As a matter of course, it is only the nearest half-year surrounding each month whose individual variation[16] determines the limits. For a practical estimation of individuals this method—averages for the months, with the variation of the year classes—is far better than yearly averages and variations.

NOTE.—The weight-height index is a very good objective scale for the weight-height relation. But we cannot demand of the practitioner—even if he is a specialist in pediatrics—that he must carry out investigations requiring even the use of logarithmic tables, even though they require but a few minutes of his time. We therefore have begun the compilation of index-tables from which the weight-height relation may be read directly when height and age are given.

We now proceed to an application of the statistical results and the table developed from them by

B. *A selection of the poorly "nourished" individuals and especially of the small individuals within the year-classes* for special study, nutrition, or medical care.

After the inspection of the figures for each child for height and for weight-height index,[17] and after the comparison has been made, the Child Hygiene Office has called in for special treatment those individuals which fell below the standards for their age, for weight-height index or for body height. These cases were submitted to special investigation and, wherever necessity demanded, recommended to the local officials for special nutritive care, or referred for medical, or hospital

[15] Thus it will be seen that Törnell's averages for height, in numerous year-classes, correspond fairly well to our highest limits, or even exceed these.

[16] Expressed by the standard-variation.

[17] Each child has its printed blank, which is annotated at the time of the examination.

treatment. Such children may be thin, weakly, or pale, without definite symptoms of illness; again, they may be pronounced rachitics, or they may exemplify myxedematous types, reduced in growth, apathetic, or otherwise peculiar or suspicious.

We have made mention of the selection of especially small children and of children with a notably small weight-height relation in proportion to age. This does not absolutely imply that either the averagely well developed, the tall ones, or those exhibiting a great weight-height figure are always to be considered satisfactory in their development. It only means that these signs of greater variation from normal, taken by themselves, call for a searching investigation.

It now is our desire to repeat our studies at the same institutions at half-year intervals. The second series—November, 1919—conducted after the first half year, already has been finished. In this manner will

C. *The individual children who frequent nurseries and children's homes, etc., be followed up and subjected to a continued control,* because a steady stream of material derived from the same social group always will yield data which permit of an objective basis of comparison. Special attention will be given to *children who remain stationary in weight, or whose weight is decreasing.*[18] Puyg y Roig lately published a series of studies from Barcelona: Monthly records from January to October showed 5% of children between 4 and 9 years were losing weight. This remarkable result also was attained, that girls were more exposed to such a loss in weight than boys; and the author quotes percentages with loss of weight for each year-class, this percentage descending with advancing years (5.2% for 4 year olds to .03 at age of 9; the values for girls vary greatly: 23.5% at 4 years, 9.8% at 6, 15% at 9 years). If we work out the averages for the year-classes, we find that the average is 2.7 in boys with loss of weight, 12.4 in girls. These facts are very remarkable, but we can draw no conclusion until a corresponding investigation has been made of the children of both sexes under our observation.

To follow up and establish a control of each individual child at definite intervals really is the most important desideratum for hygienic purposes, not only in regard to the institutions but also for the children themselves. It will stimulate the interest in, and the care of, the little ones.

[18] Here we shall make use of the absolute weight values, because they concern the same individual at different periods.

Concluding remark: A subjective estimation of development and nutritive results *may,* as I have pointed out elsewhere,[19] be good, but in itself it contains no guarantee of its value for others; again, it may be exceedingly poor, and especially so in these tender years where the weight-height relation changes from month to month, and where, if one would be particularly exact, it is necessary to consider also the sexual differences. *To a good investigation belongs both an objective control and a subjective estimate.*

Appendix

A View of the Weight-Height Relation During the Ages 0-17 Years

The opinion that the ponderal development of the body follows a wave-line has been strongly emphasized by Stratz and was credited by him to Bartels. It means that the "Periode der Streckung" would alternate with the "Periode der Fülle." This opinion almost has become a dogma and as such is repeated in some of the large text-books, such as Martin's "Lehrbuch d. Anthropologie," and Broman "Normale und Abnormale Entwickelung der Menschen." Spitzy, however, opposes this opinion, following the example of Weissenberg and adducing his records by way of proof. We ourselves cannot support Weissenberg in his establishment of seven periods. W. did not employ reliable methods in his study of the weight-height relation; furthermore, the energy of growth in height has been recorded by him in cms. and not as a coefficient of growth. The divisions established by Stratz are the following:

The first neutral period.

0—1 year: Infancy

2, 3, 4 years: Greatest ponderal development. ("Fülle")

5, 6, 7 years: Greatest height development.

---

[19] *Medicinale Revue,* 1919, Nov. and Dec.

The second, or bi-sexual age period.

Year	*Boys*	*Year*	*Girls*
8, 9, 10, 11, 12	Second period of ponderal development (" Fülle ")	8, 9, 10	Second period of Pond. devel. (Rounding of hips and legs.)
13, 14, 15, 16	Second period of height development. (Change of voice.)	11, 12, 13, 14	Second period of height development. Menstruation. Areola-Mamma Mamma areolata
17	Third pond. devel. (" Fülle ")	15	Third per. of Pond. devel. (" Fülle ")
18	Puberty.	16, 17, 18	Puberty

If we consider such a scheme as this in the light of a dogma, it will be a comparatively easy matter to find some children which fit into it. The artistic photographs of Stratz seem to go very naturally with the divisions in the scheme. But a subjective selection, such as his, very often is based on misapprehension and leads to nothing but wrong conclusions. It is urgently necessary, with such a scheme, and in order to test its truth or its availability, to carry one's demands of objectively selected examples (individuals) to its uttermost consequence. Our photographs attempt to accomplish this. As aforesaid, groups were selected, the individuals having been picked out without immediate inspection by the author,[20] the selection being based only upon the records. These groups of course must be as large as possible. A limited material limits the presence of types sufficiently close to the averages. Each child is designated by number. The group scheme makes it possible to attain a general view. A couple of rachitic children went in along with the rest. The collective material of course ought to have been vast. But an objective view of the development from year to year—our principal purpose—was possible by our method. Any sudden height increase, a definite year standing out as a separate or peculiar period, does not occur. When the said dogma—the conspectus or scheme of Stratz—has been able to obtrude itself in the literature of our subject, this is due only to mankind's immodest and absurd tendency to propose laws, to build up schematic structures and afterwards fill out the

[20] Who was not even present when the photographs were taken.

vacant spaces with suitable brickwork. If the dogmas on this subject—as on others—have found many adherents, this is due only to the comparative ease with which the masses are led. Meanwhile we admit that if one, in a subjective way and without critique, proceeds to follow up the development of individual children—e.g., one's own—he may receive an impression of certain "periods" of intensive growth in height. And such periods really do exist—but they follow the yearly seasons: there is a strong and fairly exclusive height-increase during the summer months of May, June and July. This, however, is a quite different matter; different from an alternation of height-increase and increase of ponderability. *Throughout the year-classes runs an uninterrupted height-increase from the period of infancy up to the intensive growth in height at the time of pre-puberty.* This may be demonstrated objectively by the continued decrease in these years of the weight-height relation. In all probability the relative chest circumference will demonstrate the same result. I conclude from the very limited amount of data on chest circumference taken from two series, 6 years to 14 and 12-17, including my own records, that such is the case.

The weight-height relation decreases rapidly during the first years, especially up to the fourth, where it becomes more slowly descending.[21] After 15 (weight-height index 1.14) the weight-height relation is rising. The curve for girls shows—corresponding to the relatively rapid development of this sex—a falling off only as far as year 12 (when the index is 1.14, exactly the same as in boys of 15); then it begins to rise (cf. Fig. 2, the curve). The process of physiological emaciations—or, if one prefers an objective term, the decreasing weight-height relation—is succeeded by a rise first at that year which represents the strongest growth in height; the pre-puberty period, 12 in girls, 15 in boys. Here the body, in ample time before the transition into puberty, begins an increase in weight relatively, in proportion to its height. The Bartels-Stratz dogmas hence deserve no further consideration.

The curves show that the weight-height relation for girls is less at all ages between 2 and 12, excepting years 4 and 5; see above. The curves cross each other at age 13.

It is true that ponderability of body is not identical with the weight-height relation. Yet a wave movement in the values of ponderability, such as is mentioned above, might be expected to show itself in the curve demonstrating the

[21] Stratz, et al., maintain a special period of emaciation *after* fourth year.

TABLE 6

Boys

Age Yrs.	Kristiania May & Nov. 1919	Kristiania 1917	Kristiania 1918	Stavanger 1918	Denmark ....
2	2.09	....	....	....	....
3	1.89	....	....	....	....
4	1.68	....	....	....	....
5	1.55	....	....	....	....
6	1.45	....	....	....	1.42
7	....	....	....	1.33	1.37
8	....	1.30	....	1.27	1.30
9	....	1.24	....	1.26	1.28
10	....	1.19	....	1.20	1.25
11	....	1.19	....	1.19	1.22
12	....	1.14	1.16	1.16	1.20
13	....	1.13	1.15	1.11	1.19
14	....	....	1.15	1.13	1.19
15	....	....	1.14	....	....
16	....	....	1.15	....	....
17	....	....	1.19	....	....

Girls

Age Yrs.	Kristiania 1919	Kristiania 1917	Kristiania 1918	Stavanger 1918	Denmark	Averages Boys	Girls
2	2.07	....	....	....	....	2.09	2.07
3	1.82	....	....	....	....	1.89	1.82
4	1.68	....	....	....	....	1.68	1.68
5	1.57	....	....	....	....	1.55	1.57
6	1.42	....	....	....	1.42	1.44	1.42
7	....	....	....	1.30	1.33	1.35	1.32
8	....	1.29	....	1.27	1.28	1.29	1.28
9	....	1.23	....	1.22	1.25	1.26	1.23
10	....	1.17	....	1.20	1.22	1.21	1.20
11	....	1.14	....	1.17	1.20	1.20	1.17
12	....	1.10	1.11	1.15	1.20	1.17	1.14
13	....	1.10	1.13	1.16	1.19	1.15	1.15
14	....	....	1.15	1.17	1.23	1.16	1.18
15	....	....	1.18	....	....	1.14	1.18
16	....	....	1.22	....	....	1.15	1.19
17	....	....	1.27	....	....	1.19	1.27

weight-height relation through the years. Table 6 shows the data of studies along this line; "Kristiania 1919" includes the ages 2-6, the material upon which this paper is based. "Kristiania 1917" includes the ages 8-13: Studies based upon averages worked out from a mass of material (10,000 children from the Northern counties, 1913-14). "Stavanger 1918" is the result of school records taken at the initiative

of the local statistical office. "Denmark" summarizes the records of 1000 children whose records were published in the Tidsskrift for dansk Skolehygiejne 1919, nr. 8. It will be observed that the results are closely related, hence the averages will obscure incidental aberrations. Fig. 2 (the curve) was constructed from these averages.

List of References

1. Bowditch. Quoted by Demoor and Roig.
2. Broman. Normale und abnormale Entwickelung der Menschen, 1911.
3. Camerer, *in* Pfaundler-Schlossmann, Handb. d. Kinderheilk, 1910.
4. Camescasse. Quoted by Puyg y Roig.
5. Demoor. La taille et le poid des élèves, *in* Bull. Acad. Roy. de Méd. de Belgique, sér. IV, tom. 29, Nr. 1, 1919.
6. Erismann. Quoted by Demoor and Puyg y Roig.
7. Friedenthal. Allg. u. spec., Physiol. d. Menschenwachstums, 1914.
8. Heubner. Quoted by Puyg y Roig
9. Johannsen. Elementi d. exakten Erblichkeitsforschung, 1913.
10. Key. Nord. med. Archiv., 1891.
11. Kiôrgaard. Börnesanatorierne for Köbenhavn og Omegn, 1914.
12. Kiölseth. Unters üb. d. Reifezeichem, *in* Monatsschr. f. Geb. u. Gyn., 1915.
13. Martin. Lehrb. d. Anthropol., 1914.
14. Morgan-Rotch. Quoted by Puyg y Roig.
15. Pfaundler. Körpermasstudien an Kindern, *in* Zeitschr. f. Kinderheilk, XIV, Heft, 1-2, 1916.
16. Puyg y Roig. Croissance ponderale et staturale des enfants espagnol, *in* Arch. de méd. des enfants, Sept., 1919.
17. Schiötz. Med. Rev.
18. Soley. Quoted by Puig y Roig.
19. Stavanger. Statistiske kontor: Maaling og veining av skolebarn, 1 juni, 1918.
    Statistisk maanedsskrift, Dec., 1918 (Stavanger).
20. Stratz. Der Körper des Kindes, 1904.
21. Spitzy. Die Körperliche Erziehung des Kindes, 1914.
22. Törnell. Nagot om matt, vikt och sjuklighet hos barnnedom skolaldern, Hygienisk Tidsskrift, Band 10, 1917.
23. Variot-Chaumet. quoted by Martin.
24. Weissenberg. Das Wachstum des Menschen, 1911.

BOOK REVIEW

La Philosophie Géométrique de Henri Poincaré. By Louis Rougier.

This is a resumé and amplification of Poincaré's views on the nature of mathematics, as exemplified by that branch of mathematics that seems, perhaps, most contradictory to these views, namely, geometry.

The dominant thesis of the monograph may be stated thus: The results of any mathematical investigation are derived by logistic methods from certain "first notions" and "first propositions," which have no meaning in themselves but are capable of various interpretation; and to each possible interpretation of the "first notions and propositions" corresponds an interpretation of the results, which are then necessarily true.

The "first propositions" are not really propositions, they are rather "propositional functions." A proposition is a statement that is either true or false, whereas the "first propositions" are mere "forms," and it would be absurd to speak of them as either true or false. We may choose these "first notions and propositions" as we please; the only condition to which they are subject is that they shall be consistent and sufficient for the purpose of the investigation. In geometry they have been suggested by our experience. But we now know that a consistent geometry can be constructed without Euclid's axiom (on which the theory of parallels is based) and even without the postulate of three dimensions.

Any consistent geometry is either Euclidean, Riemannian, or Lobatchevskian, and either of these geometries is applicable to any space; so that geometry gives us no information about the nature or structure of space. We usually employ the Euclidean geometry, because it is the simplest, but we may equally well employ either of the other kinds of geometry in any problem relating even to what we call 'our' space. We have adopted the point as the fundamental element of space and, therefore, our space has three dimensions; we might have adopted the straight line as element and then our space would have four dimensions; the adoption of other possible fundamental elements would have given five, six, or even more dimensions to our space.

One form of experience that has lead us to adopt the Euclidean geometry is the conception of a body moving without deformation, that is, without any change in the mutual distances of its points. But this conception must be based upon some definite system of measurement. Either of the three possible kinds of geometry is a system of measurement, and what would be no deformation of a moving body when referred to one system of measurement would be a deformation when referred to another system. Thus, the contraction that a moving body undergoes in the direction of the motion, according to the Einstein theory, when referred to a Euclidean system of measurement would be no deformation when referred to a certain Lobatchevskian system.

Moreover, to any kind of geometry belongs a peculiar system of the "first notions" that we call 'straight lines,' 'planes,' etc. According to the Einstein theory, the lines in which light moves are not straight (when referred to the Euclidean geometry), but they would be straight when referred to a certain Lobatchevskian geometry.

The monograph contains a very interesting and very complete sketch and criticism of the various systems of assumptions on which geometry

has been based by those who have attempted to systematize the subject or make it more definite.

It would be impossible to go more into detail in a review of this monograph without employing mathematical language that would be unintelligible to the general reader. In fact, most of the monograph will be unintelligible to a reader who is not familiar with several branches of the higher mathematics. Thus, what we call 'motion' is a system of continuous linear transformations that form a 'group,' and any system of measurement (system of geometry) is based on such a system of linear transformations that leave certain forms invariant.

WILLIAM E. STORY.

BOOK NOTES

A General Outline and Syllabus on Hygiene. By T. A. Storey. Wash., Govt. Printing Office, 1920. 114 p.

It is impossible to characterize this outline in the space at our disposal. Suffice it to say that the author's name itself is sufficient guarantee of its quality. First come group and intergroup hygiene, and then general and individual hygiene. The bibliography is copious and well chosen. Part Second touches upon venereal and other special diseases—also divided into individual and group, and with extensive bibliographies. Part III is on special group and intergroup hygiene, e. g. social, school, occupational, etc.

The Principles of Education. By Jesse H. Coursault. Boston, Silver, Burdett and Co., 1920. 468 p.

During the last decades of the nineteenth century psychology dominated the theory of education, but lately experimental science has been the dominant method. The scientific attitude toward education has substituted facts for opinions. The writer has been working for twelve years in the classroom and cites Hanus, Münsterberg, Royce, Dewey, McMurry, Thorndike, Gordy, Thilly and others as vouchers for his competency. He divides his material into The Individual, The Social, and The Educational Process. The writer is very conscious of his method and takes needless time to point out the obvious and withal attempts to be fundamental in a very profound sense. The very subject of his book indicates a certain degree of boldness and self-confidence which at once challenges attention, but the thoughtful student of education is liable to suffer serious disappointment if he attempts to read the book.

Ueber die Fernald'sche Methode zur Prüfung des sittlichen Fühlens und über ihre weitere Ausgestaltung. By L. Jacobsohn-Lask. Leipzig, J. Barth, 1920. 84 p.

Methodensammlung zur Intelligenzprüfung von Kindern und Jugendlichen. By W. Stern and O. Wiegmann. Leipzig, Barth, 1920. 256 p.

Untersuchungen über die Intelligenz von Kindern und Jugendlichen. By W. Minkus, W. Stern, H. P. Roloff, G. and A. Schober, A. Penkert. Leipzig, Barth, 1919. 167 p.

Die Auslese befähigter Volksschüler in Hamburg. By Rudolf Peter and William Stern. Leipzig, Barth, 1919. 157 p.

Die Intelligenz der Kinder und Jugendlichen. By William Stern. Leipzig, Barth, 1920. 335 p.

In the above five books (the first four being *Beihefte* of the *Zeitschrift für angewandte Psychologie*) we have at last a pretty exhaustive account of the methods and results of Stern and his pupils. The tests they have developed are very different from those of the Binet-Simon school, which were the starting point of all such work in America,

and a comparison of the two cannot fail to show any candid mind that each of these groups of workers has much to teach the other. In the last of the above volumes Stern sums up the methods and conclusions of his school, so that in the pamphlets and book together we have now for the first time a comprehensive survey of what may be called the Stern school of child study and testing. It would be a godsend to American students in this field, of whom there are so many, if the last volume could be translated or, perhaps better yet, a new compilation made of the material set forth in all the above.

Dr. Klages' Entwurf einer Charakterkunde. By OSKAR HERMANN. Leipzig, J. Barth, 1920. 63 p.

Klages' outline of characterology is here presented in popular form for educators and hygienists and is of much interest and suggestiveness. We are given a kind of natural history of character, with certain hints as to its relations to occupation. For the measurement of temperature, affectivity, and will we are given equations. All the tabulations are suggestive, especially that of the general structure of character and what it is made of, motivation, energy, etc.

Transformons L'École. By AD. FERRIERE. Geneva, Bureau International des Ecoles Nouvelles, 1920. 149 p.

The author of this interesting and significant brochure is impressed with the great contrast in Switzerland between the requirements of child study and the actual practices of the school. In this work he sets forth the points of disparity and suggests how the *rapprochement* between the two can be best effected. His conceptions of what is desirable evidently borrow very much from Montessori, but he sanely and wisely holds to the cardinal principle that the nature and needs of the child are everywhere normative.

French Contemporary Psychology. By GEORGES DWELSHAUVERS. Paris, F. Alcan, 1920. 256 p.

This volume epitomizes recent tendencies in French psychology, stressing most of all Bergson and Ribot, and attempts to show that there is a certain unity between even the idealistic and scientific trends in this field and that for this reason, and because of its general excellence, the state of psychology in France is at present far superior to that of Germany.

The Psychology of Functional Neuroses. By H. L. HOLLINGWORTH. N. Y., D. Appleton and Co., 1920. 259 p.

The author represented psychology in the U. S. A. General Hospital at the Plattsburg Barracks, N. Y., and saw in all nearly 1,200 cases, most of which were examined, some merely enough to test mental age while several hours each were spent on other cases. Midway in the author's stay came the armistice, the effects of which were full of psychological interest. No attempt seems to have been made to analyze intensively any case, but general ideas of this group of cases were chiefly kept in mind. There are almost no references to the really copious recent literature on the subjects here treated. Perhaps the author's most interesting results are those derived from his 116 questions which he asked his patients to answer. He takes an essentially negative attitude toward Freudianism. Desirable as it is that the psychological standpoint should be exploited to the very

uttermost in the study of psycho-neurotic cases, it is very essential that the author should have no psychological bias or at least should not display it.

Nursery School Education. Ed. by GRACE OWEN. N. Y., E. P. Dutton and Co., 1920. 176 p.

The authors approach the topic from special standpoints—psychology, hygiene, etc. The six chapters are written by as many different experts who have dealt with their subject in as many different ways. This sometimes rather wide-ranging individuality gives the book all the greater human interest and will make it more effective. It should be in the hands of all interested in the subject.

Evening Play Centres for Children. By JANET P. TREVELYAN. N. Y., E. P. Dutton and Co., 1920. 177 p.

This book tells us of the origin of the movement, the first play school center, the struggle with finance, the London centers after the grant, the movement in the provinces, vacation schools, and organized playgrounds. The volume is illustrated by a number of photographs showing the activities of children in these centers.

Laboratory Projects in Physics. By FREDERICK F. GOOD. N. Y., The MacMillan Co., 1920. 267 p.

These experiments have been organized with the purpose of giving concrete expression in the field of physics to the recent tendencies in the teaching of science with respect to aim, subject matter, and method. Units of study should be such as high school boys and girls can easily take in and should stress the organization of practical situations. The work is copiously illustrated. The laboratory references are well selected and, best of all, there is not too much mathematics.

The Socialized Recitation. By CHARLES L. ROBBINS. Boston, Allyn and Bacon, 1920. 100 p.

The chief topics treated in this volume include the weakness of the individual recitation, how to organize the socialized recitation and what it tries to accomplish, dangers to avoid, qualities to develop, the problems of the teacher, and illustrative lessons.

Short Plays. By Representative Authors. Ed. by ALICE M. SMITH. N. Y., The MacMillan Co., 1920. 318 p.

Twelve plays are here brought together to illustrate different dramatic schools and methods and which are also believed to have some moral value.

The Boise Survey. By J. B. SEARS. Yonkers, World Book Co., 1920. 290 p.

This survey is a pretty complete study of the administration of a school system in a city of about 35,000 people, and it should appeal especially to those interested in education in cities of approximately that size. The survey covers problem, organization, staff, curriculum, efficiency, progress, individual differences, health, buildings and grounds, the high school, vocational guidance, etc. It is well written and well printed.

SUBJECT INDEX

Adaptation, experiments in 302
Adenoids 188
Adolescence 101
American Red Cross 299
Americanization 103
Arithmetic 103
Armenia 103
Automatisms in study 99

Beauty 208
Bergson, Henri 301
Bibliographies
—Language 166
—Lies 105
—Metabolism 303
—Physiological growth in children 324
Boise Survey 402

Characterology 401
Chemistry 302
Child
—Adjustment of, to school 178
—Conversation of 166
—Drawings of 137
—Ideals of 297
—Lies of 105
—Mental development of 200, 301 354
—Nervous 295
—Physical development of 209, 299, 324, 371
Childhood, mental hygiene of 296
—Metabolism in 303
Child Study, general, 31, 101, 105, 166, 200, 209, 294, 301, 371, 400
Composition-writing 300
Continuation school 300
Conversation of child 166
Cost of education 300
Curriculum and individual 302

Dancing 301
Democracy in education 301
Development, mental, of child, 200, 301 354
—Physical, of child 209, 299, 324, 371
Drawing 137

Education 299, 400
—and democracy 102
—moral 209
—religious 209
Elementary school 101
English composition 300
Environment 178
Ethics 102

Foreign languages, teaching of 300
French literature 208
—Contemporary psychology 401
Fringe of a university 152
Functional neuroses 401

Gary system 103
Geometry 398
Growth of children 299, 371

Handwriting 103
—Psychology of 208
Hookworm in army 211
Hygiene 36, 67, 400
—Of school child 188

Ideals of teacher 210
Imagination 208
Industry and Psychology 281
Instruction, supervision of 209
Intelligence, effect of hookworm on 211
—Tests 400

Jesus, psychology of 205

Language, foreign, teaching of 300
Lies of children 105
Literature, French 208

Malnutrition 36
Manchester Grammar School 301
Mathematics 302, 398
Metabolism in childhood 303
Moral and religious education 209
Music, teaching of 104

Neuroses 401
Nursery school 208, 402

Objective criteria in drawing ability 137

Patriotism 102
Philosophy 210, 220
Physics 402
Plays, collection of 402
Play centers for children 402
Poincare's views on mathematics 398
Project method in education 104
—In English composition 300
Psychology and industry 281
—General 101
—Introductory for teachers 209
—Of child 294, 295, 296, 297
—of Jesus 205
—Of thrill 243
—Religious 205
Pupils' judgments of their teachers 195

Racial betterment 208
Recitation, socialized 402
Red Cross 299
Religious and moral education 209
—Psychology 205

School adjustment and psychic environment 178
—Continuation 300
—Costs 300
—Elementary 101, 401
—Hygiene 324
—Nursery 208, 402
—Secondary 301, 297
Sleep 1
Sociology 103
Space perception in children 71
Study, automatism in 99
—Methods of 90
Supervision of instruction 209
Survey of Boise 402

Teacher, ideals of 210
—Pupils' judgment of 195
Teaching in Elementary Schools 103
—Of foreign languages 300
—Of music 104
—Secondary 297
Tests 209, 400
Thrill, psychology of 243
Time sense in children 71
Tonsils 188

University life 152

Vision, conservation of 104

Wilson, Woodrow, war addresses of 104

INDEX TO AUTHORS

(The names of authors of original contributions are printed in SMALL CAPITALS.)

AFFLECK, G. B. 324
Aslan, Kevork 103
Atkins, H. G. 300
Ayres, Leonard P. 301

Berguer, Georges 205
Black, N. Henry 302
Branom, Mendel E. 104
Bryant, Sophie 209
Burgess, W. Randolph 300
BURNHAM, WILLIAM H. 1, 303

Chalif, Louis H. 301
Chancellor, W. E. 103
Chrisman, Oscar 101
Clark, J. R. 302
COHEN, JOSEPH 137
Conant, James Bryant 302
Coursault, Jesse H. 400
COURT, SOPHIE R. A. 71
Courtis, Stuart A. 103
Craddock, Ernest A. 301

Davison, Henry P. 299
Deshumbert, M. 102
DOLCH, EDWARD WM. JR. 195
Downey, June E. 208
Drummond, Margaret 294
Dunlap, Knight 208
Dwelshauvers, Georges 401

EDMONDSON, MARGARET B. 354
Evans, Elida 294

Ferguson, R. W. 300
Ferriere, Ad. 401
FORBES, HARRIET 36
Freeland, George E. 101

GALE, HARLOW 152
GARTH, THOMAS RUSSELL 90
Gehrkens, K. W. 104
Godin, Paul 299
Good, Frederick F. 402
Guradze, Hans 294

Haggerty, M. E. 209
HALL, G. STANLEY 281
Hathaway, Winifred 104
Hermann, Oskar 401
Hollingworth, H. L. 401
Hubertson, Amanda L. 294
Hutton, H. L. 300

Jacobsohn-Lask, L. 400
Jenkins, Frances 103
Johansen, Fannie O. 300

KAISER, IRVING R. 243
Kirkpatrick, Edwin A. 208

Leighton, Joseph A. 210
Lennes, N. J. 103
Leonard, A. R. 104
LEONARD, EUGENIE ANDRUSS 105
Luthy, Charles T. 103

McKeever, William A. 102
Mackie, Ransom A. 101
McMillan, Margaret 208
MACPHAIL, A. H. 188
Maner, Heinrich 294
Mayer, Eli 103
Minkus, W. 400
MITCHELL, DAVID 36
MUDGE, E. LEIGH 99
Mumford, Alfred A. 301
Murray, E. R. 209
MYERS, GARRY C. 211

NICE, MARGARET MORSE 166
Nunn, T. Percy 299
Nutt, Hubert Wilbur 209

Owen, Dorothy Tudor 301
Owen, Grace 402

Parker, Samuel Chester 103
Penkert, A. 400
Peter, Rudolf 400
Pyle, William Henry 210

Reymert, Martin L. 200
Richards, Albertine 178
Richardson, C. A. 210
Robbins, Charles L. 402
Roloff, H. P. 400
Rougier, Louis 398
Rouma, Georges 301
Rugg, H. O. 302

Schinz, Albert 208
Schiotz, Carl 371
Schober, G. 400
Sears, J. B. 402
Smith, Alice M. 402
Smith, H. B. 209
Stern, W. 400
Storey, T. A. 67, 400
Strong, E. K. Jr. 209

Trevelyan, Janet P. 402
Turkington, Grace A. 102

Warren, Howard C. 101
White, William A. 294
Wiegmann, O. 400
Wilson, Woodrow 104
Wray, W. J. 300

Zulen, Pedro S. 301

$5 per Annum Vol. XXVII No. 1 Single Nos. $1.50

THE PEDAGOGICAL SEMINARY

AN INTERNATIONAL RECORD OF EDUCATIONAL LITERATURE INSTITUTIONS AND PROGRESS

EDITED BY

G. STANLEY HALL, Ph. D., LL. D.
President of Clark University, and Professor of Psychology and Education

WITH THE ASSISTANCE OF

WILLIAM H. BURNHAM, PH. D.
Professor of Pedagogy, Clark University

AND WITH THE CO-OPERATION OF

F. W. ATKINSON, President Polytechnic Institute of Brooklyn; T. M. BALLIET, Dean of the School of Pedagogy, New York University; Professor EARL BARNES Philadelphia; Professor W. S. MONROE, State Normal School, Montclair, N. J.

MARCH, 1920

Page

THE HYGIENE OF SLEEP
By WILLIAM H. BURNHAM 1

MALNUTRITION AND HEALTH EDUCATION
By DAVID MITCHELL and HARRIET FORBES 36

ALIAS HYGIENE
By T. A. STOREY 67

NUMBERS, TIME AND SPACE IN THE FIRST FIVE YEARS OF A CHILD'S LIFE
By SOPHIE R. A. COURT 71

HOW COLLEGE STUDENTS PREPARE THEIR LESSONS
By THOMAS RUSSELL GARTH 90

AUTOMATISMS IN STUDY
By E. LEIGH MUDGE 99

BOOK NOTES 101

WORCESTER, MASS.
FLORENCE CHANDLER, Publisher

Copyright, 1919, by G. STANLEY HALL

Entered as second-class matter August 3, 1897 at the post office at Worcester, Mass, under Act of March 3, 1897.

Directory of American Psychological Periodicals

American Journal of Psychology—Worcester, Mass.: Florence Chandler.
Subscription $5. 600 pages annually. Edited by G. Stanley Hall.
Quarterly. General and experimental psychology. Founded 1887.

Pedagogical Seminary—Worcester, Mass.: Florence Chandler.
Subscription $5. 575 pages annually. Edited by G. Stanley Hall.
Quarterly. Pedagogy and educational psychology. Founded 1891.

Psychological Review—Princeton, N. J.: Psychological Review Company.
Subscription (with Psychological Bulletin) $6. 480 pages annually.
Bi-monthly. General. Founded 1894. Edited by Howard C. Warren.

Psychological Bulletin—Princeton, N. J.: Psychological Review Company.
Subscription $3.25. 480 pages annually. Psychological literature.
Monthly. Founded 1904. Edited by Shepherd I. Franz.

Psychological Monographs—Princeton, N. J.: Psychological Review Company
Subscription $4 per vol. 500 pages. Founded 1895. Ed. by James R. Angell.
Published without fixed dates, each issue one or more researches.

Psychological Index—Princeton, N. J.: Psychological Review Company.
Subscription $1.25 200 pages. Founded 1895. Edited by Madison Bentley.
An annual bibliography of psychological literature.

Journal of Philosophy, Psychology and Scientific Methods—New York:
Sub-Station 84. Bi-weekly. 728 pages per volume. Founded 1904.
Subscription $4. Edited by F. J. E. Woodbridge and Wendell T. Bush.

Archives of Psychology—Substation 84, New York: Archives of Psychology.
Subscription $5. 600 pp. ann. Founded 1906. Edited by R. S. Woodworth.
Published without fixed dates, each number a single experimental study.

Journal of Abnormal Psychology—Boston: Richard G. Badger.
Subscription $5. 480 pages annually. Edited by Morton Prince.
Bi-monthly. Founded 1906. Entire field of abnormal psychology.

Psychological Clinic—Philadelphia: Psychological Clinic Press.
Subscription $1.50. 280 pages annually. Edited by Lightner Witmer.
Monthly (9 numbers). Orthogenics, psychology, hygiene. Founded 1907.

Training School Bulletin—Vineland, N. J.: The Training School.
Subscription $1. 160 pages annually. Ed. by E. R. Johnstone. Founded 1904.
Monthly (10 numbers). Psychology and training of defectives.

Journal of International Relations (Continuing Journal of Race Development)—Worcester, Mass.: Louis N. Wilson.
Subscription $3. 460 pages annually. Founded 1910.
Quarterly. Edited by George H. Blakeslee and G. Stanley Hall.

Journal of Educational Psychology—Baltimore: Warwick & York.
Subscription $3. 600 pages annually. Founded 1910.
Monthly (10 numbers). Managing Editor, J. Carleton Bell.
(Educational Psychology Monographs. Edited by Guy M. Whipple.
Published separately at varying prices. Same publishers.)

Journal of Animal Behavior—Cambridge, Mass.: Emerson Hall.
Subscription $5. 450 pages annually. Founded 1911.
Bi-monthly. Robert M. Yerkes, Managing Editor.

The Behavior Monographs—Cambridge, Mass.: Emerson Hall.
Subscription $5. 450 pages per volume. Edited by John B. Watson.
Published without fixed dates, each number a single research.

Psychoanalytic Review—Washington, D. C.: 3617 Tenth St., N. W.
Subscription $5. 500 pages annually. Psychoanalysis.
Quarterly. Founded 1913. Ed. by W. A. White and S. E. Jelliffe.

Journal of Experimental Psychology—Princeton, N. J.: Psychological Review Company. 480 pages annually. Experimental. Founded 1916.
Subscription $3.25 Bi-monthly. Edited by John B. Watson.

Journal of Applied Psychology—Worcester, Mass.: Florence Chandler.
Subscription $4. 400 pages annually. Quarterly. Founded 1917.
Edited by G. Stanley Hall and L. R. Geissler.

THE BRANDOW PRINTING COMPANY
ALBANY N. Y.